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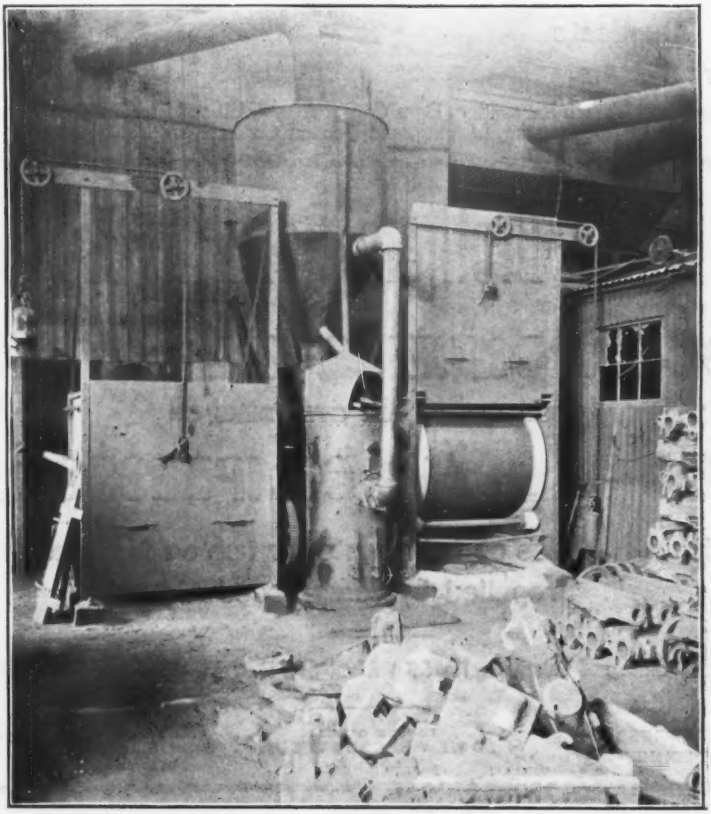
Compressed Air

A MONTHLY MAGAZINE DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

VOL. VI. NEW YORK, SEPTEMBER, 1901. No. 7.



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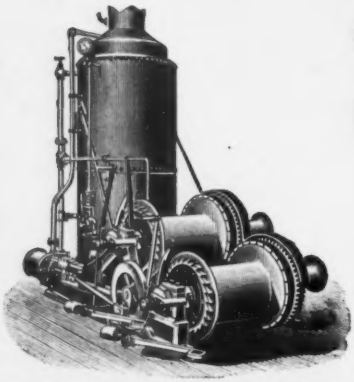

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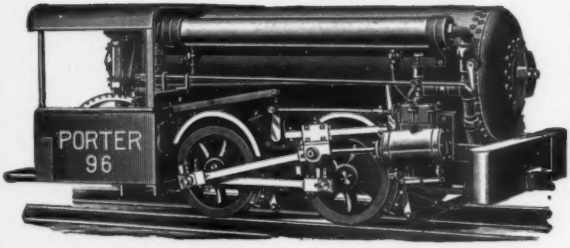

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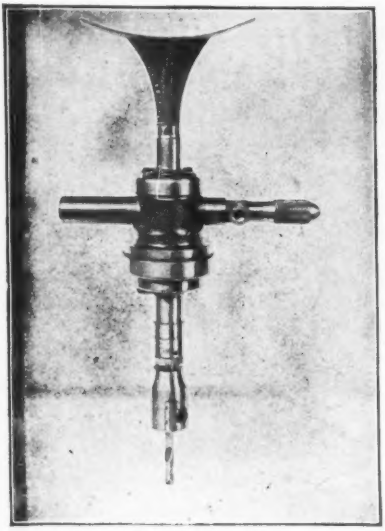

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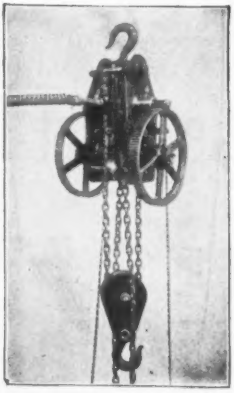

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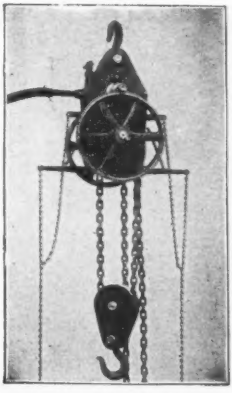

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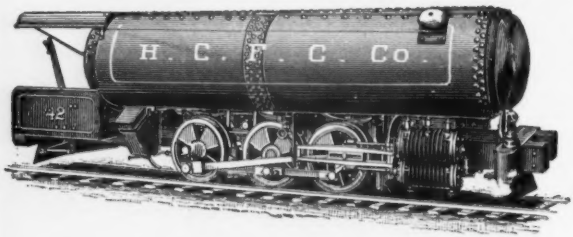

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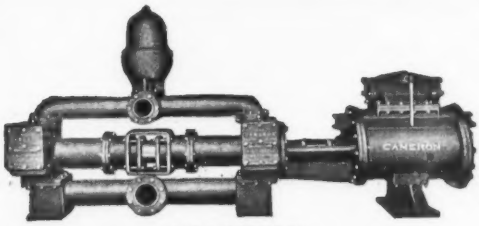
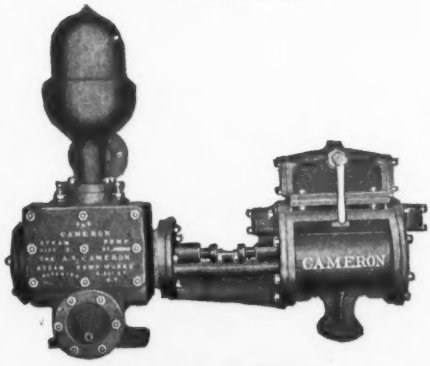


PIPE PATTERN



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Compressed Air.

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THE COMPRESSED AIR MAGAZINE.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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M. E. VARIAN, - - - - - - }

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Advertising rates furnished on application.

We invite correspondence from engineers, contractors, inventors and others interested in compressed air.

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Those who fail to receive papers promptly will please notify us at once.

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VOL. VI. SEPTEMBER, 1901. NO. 7.

In a recent issue of our esteemed contemporary, *Engineering News,* appears a description of some novelties in the electric drill line, which are interesting from the standpoint of the users of compressed air machinery.

Following early lines of electrical practice the solenoid type was developed. In this the electricity was led directly into the machine. Repeated attempts to produce a successful drill based on this principle were made by the large electrical companies, but failure resulted in every instance, because the conditions under which rock drills must operate are ever antagonistic to features which cannot be separated from any electrical machine.

Long and most expensive experience has shown that it is impossible to operate an electric drill with a pressure less than 250 volts. This voltage under any condition existing in mines and quarries is very dangerous, as the miner frequently stands in water and is, therefore, always liable to receive a severe shock. If a low voltage is used, the heating becomes a complete obstacle to the successful operation of the electric drill, whether using direct or alternating current. In the reciprocating electric drills so far attempted, referring now to those operated by the direct application of electricity, a solenoid has been used. Briefly, this is a coil of wire in the interior of which is an iron core to which the drill bit is attached. This core is caused to reciprocate by a reversal of the direction of the current or by some form of automatic make and break switch.

"Reluctance," or what may be called magnetic inertia, that is, the property of iron to risist magnetic change—that property which when the iron has been magnetized in one direction resists an attempt to magnetize it in another direction and causes a perceptible delay in the action of the armature. In other words, if the current is sent through the solenoid in one direction a perceptible delay occurs before the armature is thrown forward, if the current is then reversed in the solenoid the first magnetic effect must be destroyed and a counter-magnetic effect established; this requires time, during which interval the armature stands still or moves with a retarded motion. This effect exists whether the current be direct or alternating—further, if the current is started through a coil of wire there is an inherent resistance to its flow known as the "self-induction" of the coil; this self-induction is entirely separate from the resistance of the wire and chokes back the current preventing its instantaneous flow through the coil. Further, when the current is established any atempt to break the flow results in a counter-electomotive force or a counter-choking effect, which maintains a perceptible current in the wire for sometime afterwards, or is at least equivalent to this. There is also a resistance of the coil which further impedes the current in it.

With any form of direct acting electric drills so far made, it is possible to run the drill in open air without striking. It will be seen that this allows a drill operator to point his drill and start it in operation, and while outwardly it is running to its full limit, in reality it may be barely touching the rock. While operating in this empty fashion it is consuming as much power as if it were actually drilling.

Abandoning the electric drill, efforts have been turned towards a compromise machine, one in which the reciprocating piston has been retained because this arrangement is admitted to be the best suited to the work and power is obtained from a separate electric motor connected to the drill by a flexible shaft or some system of gears.

Cams, levers, cranks, gears, eccentrics, springs, fly-wheels, rollers and other pieces are introduced and in addition there must always be an electric motor with its own peculiar chronic complaints which are wonderfully developed by dirt, dust, grit, gas and water, always found in mines or quarries.

Another form has more recently appeared in the advertising pages of several of the enterprising trade and technical journals with an appropriate name indicating that a very strong man is needed to operate it.

In this the part which must be lifted and moved about includes the electric motor. On top of the motor is a collection of cams, gears and levers, which cause a hammer to swing back and forth, striking the end of a drill held for it by a projecting piece bolted to the front of the large motor box.

With the best form of compressed air or steam drill the drill bit must strike the rock full force with every blow, otherwise the piston strikes the head and immediately calls the attention of the operator to its inaction. This means that every stroke made by the compressed air drill is a working blow. Further, with the compressed air or steam form there is no "Reluctance," "Impedence," "Resistance," or "Lag," and the piston from the start to finish advances under the full influence of the air pressure, and as the stroke of an air drill is longer than it is possible to make that of an electric drill, the stored energy for hitting the blow is many times greater than in the electric form.

So far we have made no mention of the enormous difficulty involved in insulating the electric parts, whether on the drill or in a separate box, so that they will last even a short time. A drill of any sort to be the least bit satisfactory must be capable of striking from 100,000 to 300,000 blows in the course of ten hours and it must be able to keep this up four or five months continuously without more than adjustment of minor parts. All forms of electric drills involve the use of insulation in one place or another. To-day there is absolutely no form which will stand the shock and jar resulting from such brutal usage, or they have cams, rollers and other light parts. Further, a drill to be in any way satisfactory must be capable of enduring the worst sort of exposure and must be able to stand for days in the rain, exposed in open quarries or subject to the constant drip and splash of water in tunnels and mines. In many cases they are thrown about in out of the way places and allowed to remain for weeks covered with water, and it is absolutely impossible to construct any form of insulation that will withstand this treatment.

The frontispiece of our present issue illustrates two uses of compressed air now being employed in most progressive manufacturing works.

The first of these is the sand blast and the illustration given represents one corner in the foundry of the Ingersoll-Sergeant Drill Co., at Easton, Pa. The air blast carrying the sand is conveyed to special rooms, shown at the right of the picture, in which the castings to be cleaned are placed on gratings in the floor. A strong suction down through the grate carries out from the room most of the dust and the operators are further protected by wearing helmets and breathing masks. At either side of the sand blast is seen a box-shaped arrangement with a sliding door. This is an improved form of tumble barrel which is revolved by rollers running on the outside of the cylinder and the whole is encased in a box with a lifting door. At the center, where the bearing would be in the older form, is an inclined sand blast jet. As the barrel turns the castings are brought again and again in front of the blast and every part is fully exposed to its cleaning effect as thoroughly as if held in front of the jet by hand.

A Long Gas Transmission System.

From time to time there appears in the daily press, and to some extent, in the technical journals, discussions as to the relative merits of compressed air and electricity for power purposes. The necessity for these claims have never been quite clear to us, and we sometimes feel that this opposition to compressed air is prompted by a motive not altogether unselfish, and frequently our electrical friends are given to using rather stronger language than the facts of the case warrant.

It is generally admitted, especially by those who are not prejudiced by personal relations with electrical interests, that compressed air occupies a very large and extremely useful field. Its most sanguine friends do not offer it for every engineering need, nor is regarded by them as a panacea for all mechanical ills.

These discussions seem to start, as a rule, with installations of mine locomotives or compressed air tractors of any sort, we presume as a result of a feeling on the part of electric manufacturers that their field of railway work is being entered. The usual cry is that high pressure air cannot be used, that it cannot be transmitted, and that the losses in lines are enormous.

JUNCTION OF 36" GAS TRANSMISSION LINES.

In connection with this feature of transmission through pipe lines, we give herewith a description of a very interesting air line or series of pipe lines owned and operated by the Philadelphia Co., of Pittsburg,

and used for the transmission of natural gas from the gas producing district they control to various points of consumption.

Fig. 1 gives a general plan of the line of this company, while the figures which follow indicate its size and the character of its construction.

The natural gas lines of the Philadelphia namely: the Armstrong County, Pa., district, and the Green County, Pa., and Wetzel County, W. Va., district.

The gas from Armstrong County is brought to the city through two different pipe lines from an extreme distance of about fifty-five miles. The first fifteen miles the gas is brought through ten-inch

LAYING A 36" GAS TRANSMISSION LINE—SHOWING SIZE AND CONSTRUCTION OF PIPE AND METHOD OF LAYING.

company deliver daily to Pittsburg and vicinity upwards of one hundred million feet. At times this is increased to about 125,000,000 feet, and in summer time it diminishes to about 75,000,000 feet. The total capacity of the lines is considerably greater than the maximum delivery.

Outside of local fields contiguous to Pittsburg, the greater portion of the supply of gas is drawn from two districts, lines with pressures varying from 75 pounds to 15. It then travels through one 20-inch line thirty-five miles long, being relayed by a gas compressor passing 20,000,000 feet per day and lifting it from zero to 35 pounds. The second feeder is composed of eighteen miles of 10-inch line, nine miles of 24-inch and six miles of 30-inch. The initial pressure on this system is about 50 pounds, and is relayed by

MAP SHOWING TERRITORY OPERATED BY THE PHILADELPHIA GAS CO.

a compressor that lifts the gas from zero to 35 pounds.

The West Virginia system extends from the city boundary eighty-nine miles to the southwest into Tyler County, West Virginia. It starts from the city with 36-inch riveted steel boiler plate line, ¼ to 5-16 inch thick, made in 24-foot sections, flanged together with cast iron flanges and packed with best asbestos packing.

This pipe extends twenty miles south of the city. It then connects with a 20-inch wrought iron line, which extends eight and a half miles. To this is connected ten miles of 16-inch and eight miles of 10-inch, which carries the line to Goodwin Station, forty-six miles from the city.

Branching from the 36-inch line, between eight and nine miles south of Pittsburg, are two parallel 16-inch lines, which extend 11½ miles southward.

From this point, five miles of 20-inch and sixty-five miles of 16-inch pass through Goodwin Station, at which point the end of the 10-inch line above referred to is connected, and extend thence southward into West Virginia.

Cross lines between the two feeders extending from Goodwin Station to Tepe Farm, eight miles south of Pittsburg, are made at various points for the purpose of equalizing the pressure between the lines.

This line, with its various branches, contains upwards of 200 miles of pipe, none of which is less than eight inches in diameter. At times of maximum demand at least 100,000,000 feet of gas passes through the system in twenty-four hours.

The entire product is forced to the city by its own initial well pressure, which is so regulated as to produce about 265 pounds at the extreme West Virginia end.

This system of pipes alone (the West Virginia system) represents an outlay of upwards of $3,000,000, the 36-inch line costing more than $50,000 per mile.

The entire pipeage system controlled by the Philadelphia company includes nearly 1,300 miles of pipe.

A 36″ RIVETED STEEL GAS TRANSMISSION LINE CROSSING A CREEK ON A TRESTLE.

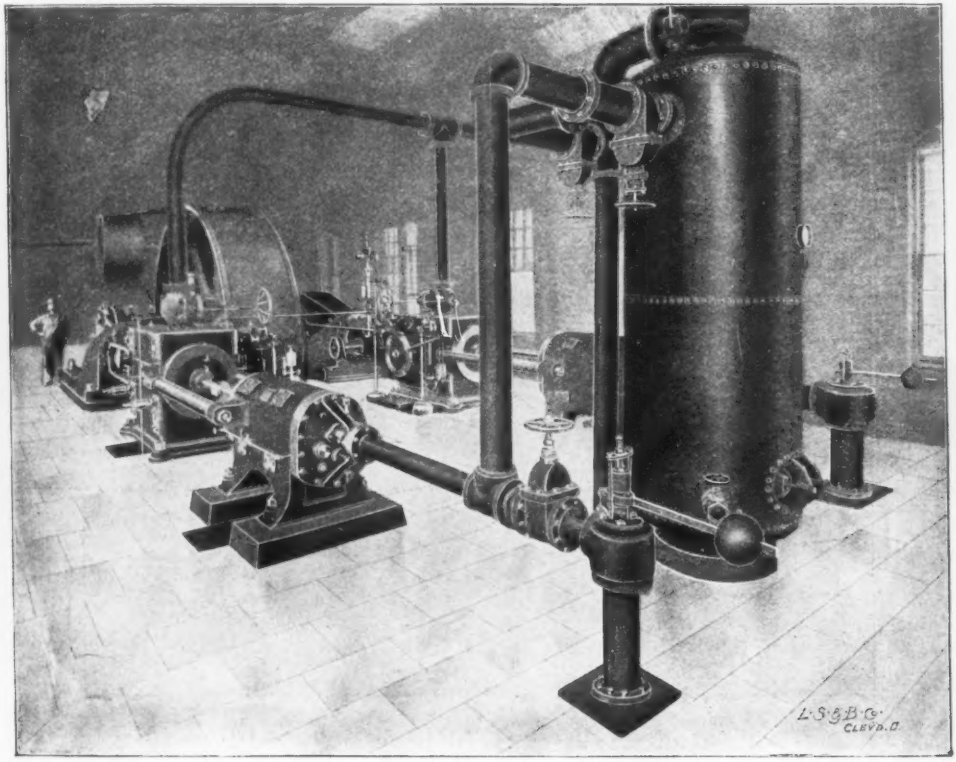
There are a number of other plants of this description in the gas regions of the United States, and we think that their existence and the use of lines of the lengths mentioned, in some cases sixty-five to seventy miles long, and as in the case of this company a total of about 1,300 miles of pipe, most of which is worked at a fairly high pressure, is pretty good evidence that air or gas can be transmitted successfully and economically.

There are very few electrical transmission lines in this country where power is transmitted to sixty-five miles or more.

We wish to express our indebtedness for the material from which this description was prepared to Mr. W. H. Hammer, Assistant General Manager of the company.

A Combination Corliss Power and Air-Compressor Plant.

A plant whose arrangement is novel in many respects has been installed recently by the Ingersoll-Sergeant Drill Co. at the quarries of the Kelley Island Lime & Transport Co., Marblehead, O. As the plan is original with the Ingersoll-Sergeant Drill Co. and illustrates the adaptability of such a combination of belt drive and compressed air power to the difficult problem presented at Marblehead, we present below some illustrations and data concerning the installation.



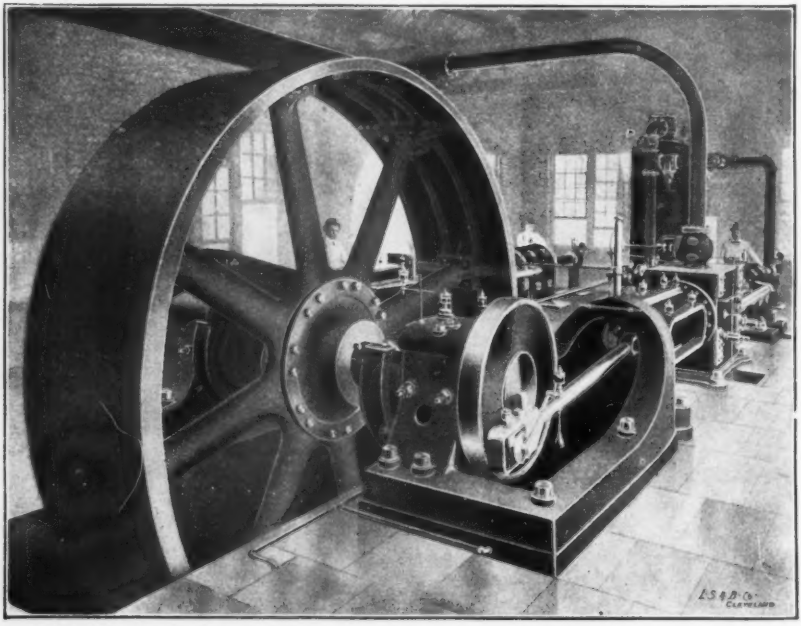
COMBINATION CORLISS POWER AND AIR COMPRESSOR PLANT.

Two 500 h. p. Corliss engines of high economy and latest tangye design are

coupled duplex to a single crank shaft on which is carried a flywheel, 18 feet in diameter with a 52 inch face, belted to a countershaft from which is driven one No. 8, one No. 7½, one No. 6 and one No. 4 Gates crusher, with two No. 3 pulverizers, three runs of Buhr mills, and necessary elevators, screens, etc. Cross-compound piston inlet air cylinders are coupled tandem to the steam piston tail rods, making a compact central plant of maximum efficiency. About 600 h. p. is allowed for the belt drive and about 350 h. p. for the air cylinders when compressing to 110 pounds air pressure.

The engines operate at constant speed and it is necessary that the belt drive be perfectly steady irrespective of the air load, which of course varies from minute to minute as the air consumption changes. To meet this situation economically, special patented regulators are attached to each air cylinder and operate entirely independently of the engine governors, on any slight rise or fall in the air pressure, to vary the amount of air admitted to the cylinders for compression; thus, if but little air is being used, the cylinder intake is nearly closed and but little power consumed. At half capacity, the regulator opens part way, so power is consumed only in proportion to the demand for air, the whole arrangement being automatic and operating without attention.

The compressed air is used at the Marblehead installation for operating Ingersoll-Sergeant rock drills scattered about five quarries, several within a few thousand feet, some over a mile away from the compressor, others a mile and a quarter in a different direction. Air also drives a dock pump for a lake water supply and an air lift pump in a distant quarry for well supply; hoists, pumps for drainage of quarries, forges, repair shops for the Lakeside & Marblehead Railroad, etc. All the power generating apparatus



FRONT VIEW—CRANK HOUSING OR OIL GUARD REMOVED.

is concentrated into one central station cared for by one man, no steam being used in the adjoining or distant quarries except for locomotives. As this averages the load by evening up all around a relatively small boiler plant, economical in coal, furnishes all the steam, doing away with all portable boilers, saves repairs, eliminates the hauling of coal and water for a large number of scattered boilers with expense of tending them on cold nights and effects important economies in many different directions.

During certain periods of the year either side of the engine and one air cylinder will carry the load, the other side being disconnected in a few minutes, thus avoiding the fuel waste of running a large engine considerably under its economical load and providing for any emergency. The air cylinders are cross-piped to admit of either side being available, and either air piston may be uncoupled from the engine on a moment's notice. In case of extraordinary demand, the air cylinders may be thrown out of series and used as single stage independent compressors. Air is compressed more economically than would be possible through belt driven compressors and with less machinery, the direct connection from steam to air piston with a straight rod eliminating friction, wear and other losses. One compact foundation answers, and when 1,000 h. p. is wanted on the wheel for belt driving alone, the air cylinders may be removed and coupled to a smaller and independent pair of Corliss engines to be added if necessary in the future.

Several miles of uncovered air line is used, air power being insatntly on tap with the turning of a valve in any part of the quarries. Provision has been made against freezing by removing the moisture from the air after compression. The engine room is of rock faced limestone with cement floor, and the surroundings, arrangements and appearance of the plant are unusually attractive and well designed. It has been found that in operations requiring a small or moderate power equipment a belted compressor driven from a gas, gasoline or oil engine will furnish air power at an especially low cost for fuel and attendance. A central, compact plant of the kind illustrated can usually be cared for by the hoist or spool tender and steam eliminated altogether, making a licensed engineer unnecessary.—*Iron Trade Review.*

Westinghouse Air Brake Co. at the Pan American.

The accompanying illustration gives an idea of the exhibits of the Westinghouse Companies in the Exhibition proper. Although in the city of Buffalo and vicinity the Westinghouse Electric & Manufacturing Company alone has over 150,000 horse-power of electrical machinery in operation, including the ten 5,000 horse-power generators which this company installed at Niagara Falls at a time when the largest electrical machine built was about 2,000 horse-power in capacity, it is this installation in the Pan-American that has made it the most brilliantly lighted of expositions and contributed so successfully to its operation.

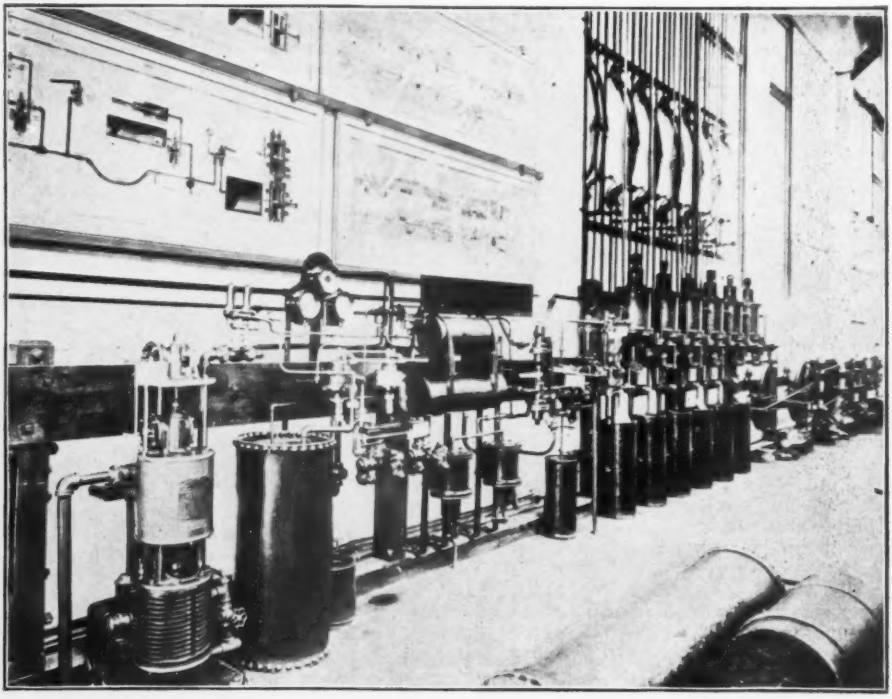
Almost every traveler by rail knows that his safety and comfort are in a large measure due to the Westinghouse air brake, which for thirty years has been the standard appliance for arresting the motion of trains. A million and a quarter of these brakes are now in service throughout the world. Those familiar with engineering affairs are acquainted with the very extended use of the steam and gas engines built by the Westinghouse Machine Company. The Union Switch & Signal Company manufactures every known variety of automatic and semi-automatic railroad signals, frogs and switches, and mechanical, pneumatic and electrical interlocking mechanisms of all kinds.

The operation of two gas-engine generating sets is one of the features of greatest interest in the Electricity Building. The large unit consists of a 300 horse-power three-cylinder, four-cycle gas engine, direct-coupled to a 2,200-volt two-phase, revolving field alternator. The smaller unit is a three-cylinder, four-cycle gas engine, direct-connected to a 125-volt, direct-current generator. The power furnished by the large unit is employed partly in supplying current to 130 Nernst lamps at 220 volts and partly in operating numerous Westinghouse induction motors applied to stationary service.

The small gas-engine generating set is used for exciting the large alternating-current generator for lighting the switch-

board and for charging the storage-sparking outfits for both gas engines. It is used also for operating motors and other machinery.

In the Railway Exhibits Building we find the exhibit of the Westinghouse Air Brake Company. A rack representing a six-car train, including the locomotive, is equipped with the high-speed brake. This



VIEW OF THE WESTINGHOUSE AIR BRAKE COMPANY'S EXHIBIT OF HIGH SPEED BRAKE FOR SIX-CAR PASSENGER TRAIN.

installation of an apparatus now coming into general use shows the proper method of application and operation. An attendant is present who operates it and fully explains its merits. Each part is duplicated and cut in section, and connected in tandem to its relative part, so as to show every feature of its application. One of the interesting features of this arrangement is the 9½-inch air pump top-head cut in section and working in unison with the top-head on an operating pump, showing in detail the movement of the very simple valve motion of this device.

The air is supplied by four motor-driven duplex air compressors, which are also part of this exhibit. These compressors are especially adapted to supply compressed air for air brakes on electric motor vehicles as well as various other industrial uses. A complete equipment of both the straight air and the storage system of air brakes for electric cars is so arranged on the platform as to show their application to the car.

The American Automatic Slack Adjustor, in addition to being shown in connection with the six-car high speed brake train, is also attached to the cylinder on a neatly designed model engine truck,

likewise a model locomotive frame with three pairs of drivers connected, and a complete equipment for a passenger car, These models are so designed as to show the proper method of applying this device to the standard equipment, and its operation in automatically regulating the brake piston travel.

The Westinghouse Automatic Air and Steam Coupler, as its name indicates, is so designed that the air and steam pipes usually carried underneath the cars are coupled automatically whenever the cars themselves are coupled and with even greater certainty, there being no locks, catches or other parts which require manipulation by the train men. In coupling it is only necessary to push the cars together, and when uncoupling to pull them apart. This device permits cars to be coupled or uncoupled with the maximum rapidity and certainty, and makes it unnecessary for trainmen to go between the cars. Arrangements are provided for opening and closing, from the side of the car or the platform, the cocks in the train pipes.

The Ammonia Compression System.*

Refrigeration may be produced in different ways; for instance, by melting or dissolving solid bodies, as in mixing salt and snow. Two parts of snow and one part of common salt reduces the temperature of the mixture to 5° below zero, while three parts of snow and four parts of potassium produces the great reduction in temperature of from 32° to 51° below zero.

Furthermore, refrigeration can be produced by absorbing heat of compressed gases through expansion, as in compressed-air machines, or finally by evaporating liquids which have a low boiling point, as in ammonia, carbonic acid, or even liquid-air machines.

In practice, and principally where temperature of medium range are wanted, the ammonia compression machine is generally adopted, and this paper will be given to the principle and operation of refrigerating machines of this type only.

Before entering into the practical side of the question it may be well to demonstrate a few theoretical points which appear in the compression and expansion of gases. All gases in changing their volumes through compression or expansion follow Mariotti's law, which we express through the formula $v \times p = v_1 \times p_1$ (v and v_1 for volume; p and p_1 for pressures).

If in this equation two factors are given, the third one is easily found. For example, given a volume (v)=40 cubic inches under pressure (p) of 20 pounds, and it is desired to find the volume under a pressure of 10 pounds (p_1)
Hence:

$$v_1 = \frac{40 \times 20}{10} \qquad v_1 = \frac{800}{10} = 80$$

In compressing a gas we notice, besides the changing of volume and pressure, another factor, which is the creation of heat. In other words, by compressing a gas we convert the mechanical work into its equivalent of heat.

Now, if we assume a constant temperature during a compressing process after Mariotti's law, the graphic form of compression would be as the isothemal curve. But as temperature and pressure are always in direct connection, and a gas creates heat during compression, it is evident that our compression curve must show different, and a gas compression in this manner forms the adiabatic curve. Therefore, in compressing a gas, if no superheating or radiation takes place during the operation, we understand a gas is compressed adiabatically.

This thermodynamic point holds good for all refrigerating agents, as air, ammonia, carbonic acid, etc.

Through mathematical calculation the relations of work and heat can be determined and upon this basis all refrigerating machines are defined.

In practice, where economical results are what everybody is looking for, there are other and different properties which are of great importance in applying a refrigerating medium and obtaining high efficiency.

The physical nature of the substance to be used as a refrigerating agent must be taken into consideration, such as the latent heat of a liquefied gas, and if the gas becomes a liquid under moderate pressure and temperament, these are factors of importance, as the latent heat of evaporation almost represents the amount

*Abstract of a lecture delivered before Illinois No. 28, by T. F. Andersen, Illinois No. 38.

of cold that can be produced in any refrigerating machine.

Owing to these properties, such as high latent heat of evaporation, requiring a comparatively low pressure for liquefaction, etc., the ammonia machine is given the foremost rank for refrigerating purposes and is now used in all countries.

Another property to be looked at is the critical temperature of a gas. Under the term critical temperature we understand that a gas, after reaching a certain degree of heat, cannot be liquified, no matter how much pressure may be applied.

	Boiling point.	Latent heat.	Critical temp.
NH_3	—28	555	266
CO_2	—61	180	88
L. Air.....	—312	144	—284

The above table gives us the different temperature for these different refrigerating agents, ammonia, carbonic acid and liquid air. Prof. Linde carried out a series of tests, making a direct comparison between an ammonia machine and a CO_2 machine, when both working under the same condition. (The substance to be refrigerated was brine, and a temperature of 15° maintained.)

At a condenser temperature of 72° he found the coefficient of performance in the CO_2 machine was 82% of the coefficient of performance in the ammonia machine, and when the temperature of condenser was raised to 95°, so as to be above the critical temperature of CO_2, then the coefficient was 50% of that of an ammonia machine.

Prof. Linde found further that if he artificially cooled the liquid before allowing it to pass through the regulating valve and the temperature was lowered to that of the refrigerator itself, then he obtained the same refrigeration whether he used NH_3, or CO_2. Taking these experiments from such high authority as Linde for granted, there can be very little criticism as to which of the two refrigerating agents must be given the preference, and it is evident that a CO_2 machine may give good results while working with condensing water of a low temperature, but becomes a very expensive machine to operate where tropical conditions prevail.

In a compression machine the refrigerating agent used is known as anhydrous ammonia, a chemical combination of one atom of nitrogen with three atoms of hydrogen and expressed through the symbol NH_3. At ordinary temperatures ammonia is a gas, while at the temperature of 30° below zero it becomes a liquid at atmospheric pressure. The latent heat of ammonia is 555 and at a temperature of 900° it will decompose into its elements. Ammonia is a highly suffocating gas, but it is not combustible nor explosive. It is often claimed that ammonia gas forms an explosive mixture with air similar to a mixture of air and illuminating gas, but scientists in no instance have succeeded in producing an explosion and in heating the gas to a temperature of 900°, where decomposing takes place, the free hydrogen may be burned and shows a yellow flame.

Nearly all cases where explosions of gas mixture in refrigerating apparatus were reported they could be attributed to the presence of small quantities of hydrocarbon gases, which are formed through the decomposing of lubricating oils, and when ignited through excessive heat may lead to an accident of explosive nature. Statements have proven that destructions of this kind frequently happen while the apparatus is being tested with air pressure.

Engineers should be, therefore, very careful in applying air tests to a pipe system that has been in operation for a length of time and where changes or repairs call for an air test. In such case the machine should be started and run very slow and operated at intervals, so as to give plenty of time to cool the compressed and heated air before reaching the high-pressure mark. In fact, the only case where I can see a possible danger in an ammonia machine lies in any part of the apparatus that may fill up totally with liquid ammonia and then have the connections closed. Under this condition a rise in temperature would rupture the apparatus by the expansion of the liquid, the same as if a cylinder filled with water and then subjected to a temperature below freezing point.

Frequently it happens that the operator of an ice or refrigerating plant may have to draw liquid ammonia from the system into receptacles. The utmost care should be taken in doing so, and ample precaution given to leave some room for expansion.

The refrigerating effect in ammonia machines of the compressed type em-

bodies a cycle of operations. Liquid ammonia is converted into a gas through evaporation, in which state, after being saturated with heat, it enters the compressor. During compression the mechanical work is converted into heat and the heated gas is forced into a condenser, which apparatus through cooling water removes the heat and causes the ammonia to assume its original state as a liquid.

The ammonia compressors are classified into the dry gas and the wet or humid gas machines. An ammonia gas is called dry when it is not in contact with the liquid from which it was originated, while a humid gas is more or less saturated with particles of liquid and enters into the compressor in form of vapor or fog. Which of the two is the better and more economical one is an open question to-day. Numerous articles have been written for and against either one of the two systems, but in all tests where the same condition prevailed the results are practically the same.

Speaking theoretically it is difficult to see where the advantage of one to the other can be determined. The most work a machine can perform is certainly accomplished by keeping the range of temperatures as small as possible, or, in other words, the temperature of the refrigerating agent during evaporation should not be kept lower and during compression not be higher than is absolutely necessary.

This should be impressed on the mind of every engineer, as it is the most important point in running ice machines successfully. How an engineer can reach this point of economy is entirely a matter of practice and experience, as it depends on the conditions of the plant and many different observations, which must be taken into consideration while operating the machine.

It depends on the amount and temperature of cooling water, the amount of condenser surface, whether the rooms have to be kept far below or above the freezing point. It further depends on the amount of square feet of evaporating coils and in the case of manufacturing block ice how many receptacles are placed in the brine tank, etc.

There are hardly two plants working under the same conditions and it is rather difficult to give a certain rule, which would express the different pressures to be obtained in operating an ice or refrigerating plant.

The engineer running a dry gas machine tries to enter the gas nearly saturated with heat as possible and allow no liquid to enter the compressor; while the operator of a humid gas machine will watch the temperature of the ammonia gas leaving the compressor, which should be kept high enough to prevent superheating.

Some years ago reliable tests were made with humid gas by Prof. Schroeter in Germany, who operated a Linde compressor, while Prof. Denton in this country has conducted the experiments and tests with a dry gas machine. The results may be called practically the same in both cases, although the facts gave a somewhat inferior efficiency for the dry gas machine.

The capacity of refrigerating apparatus is commercially rated by the tons of refrigeration that are produced in twenty-four hours. In my opinion, the term tons of refrigeration is, in many instances, not quite correct and often misleading. As the output of a machine depends at all times on the conditions under which it is operated and as the refrigerating capacity of a compressor depends directly on the temperature, pressure and weight of the gas handled per revolution, these items should always be represented in describing a machine to a prospective purchaser. The correct way in stating the refrigerating capacity of a machine would be, therefore, to give the cubic inches of gas under given pressures that the machine will handle and produce a certain amount of regrigeration.

A machine large enough to keep the temperature of a room at 40° will certainly not perform the work if a temperature of 5° is required. Why? Because the difference in temperature varies to a great extent, and as the refrigerating capacity can only be measured by the amount of ammonia in weight passing the compressor, we may look at an ammonia table, which illustrates this fact through the following simple calculations:

Supposing the temperature of the saturated ammonia entering the compressor be equally proportioned in both cases, or, in other words, let the thermometer indicate a difference of 15° between the temperature of the refrigerated room or

brine and the ammonia gases. This would give us 25° for a room of 40° and 10° below zero for a room of 5°.

In looking up an ammonia table we see that gas of 25° corresponds with a gauge pressure of 39 lbs., while a gas of 10° below zero requires 9 lbs. of pressure per square inch. Assuming the condenser pressure, say 1.53 lbs., equal in both cases, the amount of ammonia to be pumped in cubic feet per minute to produce one ton refrigeration in twenty-four hours would be, after Prof. Liebel's table, for maintaining a temperature of 40°=2.15 cubic feet, and for 5°=4.86 cubic feet.

The difference of these figures show clearly how the refrigerating effect depends entirely on prevailing conditions. It is, therefore, necessary for the operating engineer to study the different conditions of the plant under his charge, in order to get the best refrigerating effect with the smallest amount of fuel.

Frequently you meet an engineer who brags about the superiority of his machine and the skill of his management in running the plant by showing the visitor the low back pressure and temperature of brine he obtains. Very often you may find the temperature of the brine in the neighborhood of zero, where in reality the conditions require a temperature from 15° to 20°. The facts are here, while his machine may run very smooth and easy, the compressor is too big for the work and the proprietor has to stand the difference in paying high coal bills.

The Kellogg Tunnel—Bunker Hill and Sullivan Mines, Idaho.*

The tunnel known as the Kellogg tunnel is situated at Kellogg, Shoshone county, Idaho, and is being driven by the Bunker Hill & Sullivan M. & C. Co., for the purpose of developing a group of mines worked by them, and known as the Bunker Hill and Sullivan mines.

The mines up to the present time have been worked through tunnels upon the property, but as the ore on these levels and above is fast becoming exhausted, the necessity of hoisting and pumping, or driving a tunnel at some lower level, became apparent. The mill of the company is situated some 9,000 feet from the mines, at an elevation of 800 feet below the lowest working level, the ore being conveyed to the mill by a Bleichert aerial tramway. It was therefore decided to drive a tunnel from the mill to the mine, thereby furnishing an outlet for the ore and drainage for the water, besides giving some 750 feet of stoping ground.

From the very outset the aim has been to make the greatest possible progress. The first difficulty encountered was the removal of waste material after blasting. Shoveling by the day and under contract was tried with but little difference in results. A single drum, double cylinder hoisting engine was installed, mounted upon a wooden frame, so that loaded cars holding 1 cubic yard of waste could pass under. A second wooden frame, with incline floor, was used just in front of the hoist. This frame was so arranged that two of the dump cars could be pushed under the end of it at the same time. A No. 1 scraper, or slusher, loaded with muck or waste, was hauled up this incline floor by the hoist to an opening in the frame over the car, when the scraper load was dumped into the car and the scraper returned for another load. Two scraper loads usually filled a 1-yard car, and never more than three were required. When the first car was loaded it was pulled forward and the second car brought under the loading opening. When both cars were loaded they were together pushed to a position on the track some 50 to 100 feet below, where the trains were made up, and the two more empty cars from the siding were brought to be loaded. A section of the hoist frame and mucker frame is shown in the cut. Sufficient powder is used to break the rock, which is a quartzite, to a suitable size to be handled by the scraper.

Five men are employed at the removal of waste—one to operate the hoist, one to attend the dump cars, placing and removing, and three loading and attending the scraper. The time required to move 40 to 50 cubic yards of waste is two to two and one-half hours.

When it becomes necessary to advance the incline floor, or mucker, a car underneath the frame carrying four jackscrews, made from worn out machine-drill feed screws, is used. The framework is jacked up until the entire weight is upon the car. The frame is then pushed back to allow the placing of new track. When the new rails are laid, the frame is advanced

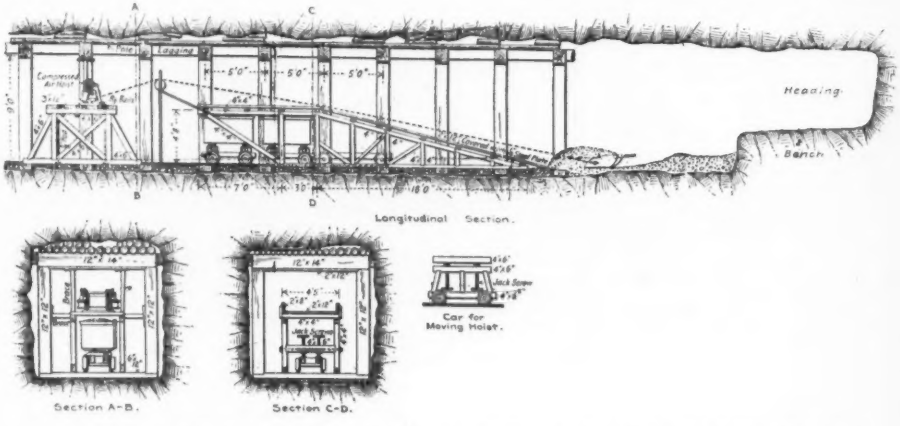
*Ulysees B. Hough in Engineering News.

nearer the face of the tunnel, lowered to the floor, and is again ready for use. To move the hoist, a framework mounted upon a car truck is run under it, and four jackscrews, made from worn out machine feed screws, are used to jack the entire hoist and frame from the floor, when it is ready to move forward. The time consumed in moving both hoist and mucker will not exceed twenty minutes for the five men. These frames stand the work well. Both the present hoist frame and the mucker have been in use for fifteen months and have been used to drive 3,400 feet of tunnel. Both appear to be in fair condition.

The drills used are the No. 4-A Rand air drills. Two machines are used at a time, both working upon the same bar. They are driven by compressed air at ninety pounds pressure, supplied through a 4-inch pipe from the air compressor supplying the mine. In untimbered ground a heading is driven 10 to 20 feet in advance, three rounds being shot in the heading to two in the bench.

All material and waste is handled to and from the tunnel by a General Electric motor of four tons weight, running upon a track of 24-inch gauge. This motor hauls a train of fifteen loaded cars on an average, though as much as twenty cars are sometimes handled. The tunnel has a grade of 0.5% for the first half and 0.3% for the remainder. Rails of thirty pounds to the yard are being used. The track is single, aside from the 200 feet of siding near the face, which is moved from time to time as the tunnel advances.

The smoke and gases are removed through a 22-inch galvanized iron pipe, made of No. 18 iron, by an exhaust fan. This fan, in fifteen or twenty minutes, will remove all smoke and gas after blasting to enable the men to return to work; and though the pipe is now over 8,000 feet long, the time required to remove the smoke seems no longer than at first. This pipe is made in 18-foot lengths, and all seams are riveted and soldered. Where the lengths join, heavy sheeting is wrapped around the joint and painted with coal tar, so there is little or no leakage along the line. The fan is driven by a 24-inch Pelton water motor, working under a head of 300 feet. An auxiliary air engine is always in readiness in case of any accident to the water motor.



THE KELLOGG TUNNEL, BUNKER HILL AND SULLIVAN MINES, KELLOGG, IDAHO.

The progress of the tunnel has varied much on account of the variations in the ground encountered. In the month of October, 1898, an advance of 354 feet was made, being the most progress made in any one month. In February, 1899, an advance of only 53 feet was made for the month. In this month a considerable volume of water was encountered, with running ground, and little or no progress was made for a week at a time. The average progress to the present has been 7.5 feet per day. It has been found necessary to timber about one-third of the tunnel.

On the completion of the tunnel and its connection with the mine, ore will be hauled to the mill by electric motors. From 800 to 1,000 tons will be handled through the tunnel daily to supply the concentrator.

Machinery at the Glasgow Exhibition.

Near the centre of the Machinery Hall, at Stand 532, the Ingersoll-Sergeant Drill Co. have a large and interesting exhibit occupying something like 1,000 square feet of space. Their exhibit consists of their well known air compressors and rock drills for quarrying and mining purposes. They have on view four air compressors all in motion; one of their class "G" duplex piston inlet type with steam cylinder 16 in. diameter, and compound air cylinder 15¼ and 25 inches diameter by 18 in. stroke, having a free air capacity of 1,130 cubic feet per minute; one class "A" piston inlet straight line type with steam cylinders 14 in. diameter and air cylinder 14¼ in. diameter by 18 in. stroke, fitted with the Meyer expansion valve gear; one of class "B" piston inlet belt driven type having an air cylinder 12¼ inches diameter by 14 in. stroke; and one small electrically driven air compressor with motor connected direct to the geared flywheel. This company also have in the outside grounds of the Exhibition two of their class "J" type air compressors, electrically driven, with motor connected direct to geared flywheel. The class "G" type of compressor (fig. 1) is a high duty air or gas compressor, and is a thoroughly reliable machine with a low steam consumption coupled with simplicity and ease of management. The quality and finish of the workmanship are up to a high standard of excellence, special care having been taken in the construction of all the inner working parts to ensure smooth and even running. Attached to the machine is a regulator which prevents dangerously high speed in case of loss of air pressure from any cause, and automatically controls the speed at all times in proportion to the demand for air, thus using steam only as air is used. The compressor is fitted with piston inlet air cyclinders, with vertical lift discharge valves; cylinders, heads, discharge valves, and stuffing boxes being water jacketed. The steam cylinders, as noted, have Meyer's expansion valve gear, adjustable while the machine is running for any cutoff from one-quarter to three-quarters stroke; the steam cylinders are well lagged, and all the bearings of the engine are fitted with high grade phosphor bronze composition. The air cylinders are tied to the steam cylinders with heavy rigid distance pieces, solidly fastened with turned bolts fitted into reamed holes. This type of com-

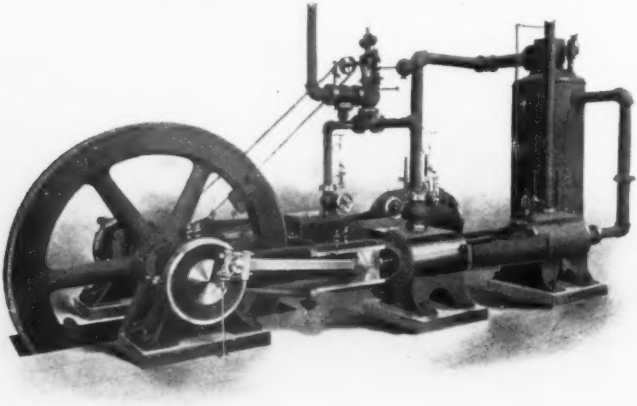


FIG. 1.—CLASS "G" INGERSOLL-SERGEANT AIR COMPRESSOR.

pressor is principally used amongst collieries and where large installations of pneumatic tools are required.

The class "A" piston inlet straight line compressors (fig. 2) are entirely self-

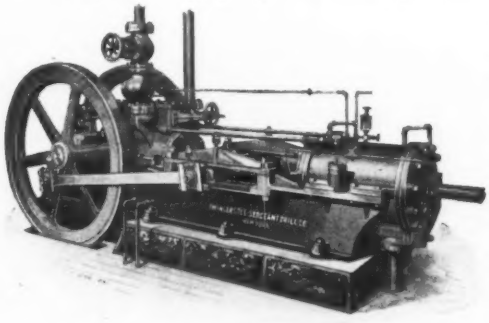


FIG. 2.—CLASS "A" INGERSOLL-SERGEANT AIR COMPRESSOR.

contained, the shaft and both cylinders being carried on a single solid bed. This construction admits of great strength and capacity in small space, inexpensive foundations, and easy transportation, and is well suited for general mining and tunnelling work, where a machine is expected to stand the most severe usage in regions often remote from facilities for repair work. To effect a thorough cooling, cold water is kept circulating through the heads and around the discharge valves, as well as completely around the cylinder, thus presenting a cold surface to the air at the end of the stroke where it is hottest. This cold head is of greater value as a cooling surface than the jacket round the cylinder, because the air is hottest near the end of the stroke, and when the piston is at this point, most of the cylinder jacket is on the other side of the piston, where no work is being done. The regulation of the air compressor is effected by the Ingersoll-Sergeant regulator or unloading device. This regulator is so arranged that, when the pressure rises beyond the desired point by reason of stoppage of the machinery using the air, a passage is opened between both ends of their cylinder, whereby the air at full pressure is admitted on both sides of the piston, holding the inlet valve slightly closed. The piston, having air pressure on both sides of it, is exactly balanced and moves in equilibrium, the air pressure following it on both sides, back and forward; the result is a balancing of forces, and no more power is required to move the piston than would be if both airheads were entirely removed. At the same instant that this connecting passage is opened, the steam is automatically throttled to a point which just admits sufficient steam to keep the engine turning at slow speed and to overcome the friction of the working parts. The compressor will run in this way until the air pressure has been lowered by being drawn away, when the passage is closed, the steam automatically turned on, and the inlet and discharge valves resuming their regular movements, the work of compression goes on in the regular way.

The class "B" and class "J" electrically driven compressors are used almost exclusively for tool work, and are usually driven by belting or rope transmission. These compressors are also fitted with the automatic regulator and unloading

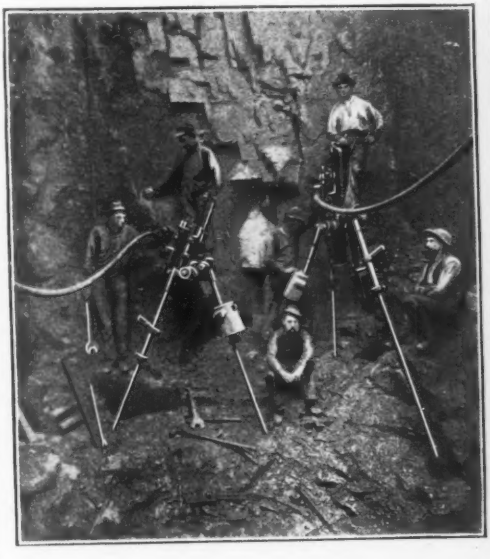


FIG. 3.—INGERSOLL-SERGEANT ROCK DRILL.

device as already described for the class "A" machines; in fact, the details of construction are almost similar to the latter, and hence need not be further described.

The Ingersoll Company, with their compressors, are supplying a number of firms in the Exhibition with compressed air for working their exhibits. In their space in the Machinery Hall the firm are also showing some of the well known Ingersoll-Sergeant rock drills along with their mountings and tripods suited for working in quarries, mines and tunneling.

Among these fittings shown are the Sergeant patent adjustable tripod, with weighted legs, which is generally used for drilling holes in a vertical position such as in the bottom of a shaft; the patent adjustable column and shaft bar for drilling holes in the face of a tunnel, and the Ingersoll-Sergeant quarry bar, which is most generally used mounting rock drills for working in quarries. The horizontal quarry bar admits of much faster work than can be done on the tripod, as a number of holes can be drilled with the one setting, whereas with the tripod the drill has to be shifted into a new position for every hole bored. With the bar, too, there is no time lost in getting the bit plumb on the line, and if set right for the first hole, all the others drilled at that setting will be in line top and bottom, insuring perfectly accurate work without depending on the carefulness of the attendant. It can also be made mounted on wheels to facilitate moving when desired. On their outside space in the grounds, on the north side of the Kelvin, the Ingersoll-Sergeant Company have placed several large granite and whinstone blocks 2 to 3 feet thick, on which they have rock drills in operation to show to visitors the method of working them.—*The Colliery Guardian.*

FIG. 4.—INGERSOLL-SERGEANT ROCK DRILL.

The New Compressed Air Equipment at the Wangler Boiler Works.

J. A. Prescott, the St. Louis representative of the Rand Drill Company and Pneumatic Engineering Company, New York, has just about completed the installation at the shops of the Joseph F. Wangler Boiler and Sheet Iron Works Company, Ninth and Mullanphy streets, of one of his company's Imperial, type 10, air compressors, with a capacity of 245 cubic feet of free air per minute. This compressor is to furnish the power for

the various air tools and appliances with which the Wangler company are equipping their plant—pneumatic riveters, drills, calkers, etc., in order to keep their works thoroughly abreast of the times. The Imperial, type 10 compressor, is of the duplex form, with cranks quartering, or 90 degrees apart. There are two double acting steam cylinders of equal size. There is one high pressure and one low pressure air cylinder, both of which are double acting. The steam cylinders are at one end of the frame; the air cylinders are at the opposite end of the frame. The piston rod of the high pressure air cylinder is connected to the same crosshead as the piston rod of the right hand steam cylinder, and the piston rod of the low pressure air cylinder and piston rod of left hand steam cylinder are likewise connected into the same crosshead. By this arrangement of steam cylinders at one end of the frame, and air cylinders at the other end of the frame, the builders obtain a machine that is more compact and more accessible than is possible where the steam and air cylinders are set tandem at one end of the frame. By simply taking off the outer cylinder heads access can be obtained to the interior of all of the cylinders. Both steam and air cylinders are overhung from the main frame, and are not dependent upon the foundation for support or alignment. The flywheel is heavy and is located near the centre of the machine, lengthwise as well as crosswise, and thus the weight is evenly distributed on the foundation, which is not the case in the ordinary form of compressor where the flywheel is located near one end of the foundation. The main frame for both sides of the duplex compressor is in one piece and high enough to swing the flywheel clear from the floor. The metal is generously distributed to give the greatest amount of strength and stiffness. It has a broad spread upon the foundation, all ribbing is on the inside, and it presents a massive and handsome appearance. The main bearings are cast solid with the frame. By means of special machinery both ends of the frame are bored and faced to receive the steam and air cylinders and the main bearings are also bored and faced at the same chucking to receive the renewable babbitt bushings. The bearings are adjustable in two directions, and when worn out the old babbitt shells can be removed and new ones put in their places by simply raising the shaft sufficiently to take the weight off the bottom part of the bearings. Thus no rebabbitting is necessary, and correct alignment is preserved in spite of wear. The flywheel is made very heavy to insure smooth running, and has a broad face turned and polished to receive a belt should it be desired to run the compressor by belt power temporarily, or take power from the compressor to run other machinery. Air cylinders and heads are made of a special mixture of charcoal, iron and selected scrap, and the inner walls are thick enough so that they can be rebored, if necessary. Efficient water jackets are provided, through which water circulates to take up the heat of compression. Air inlet valves are of the Corliss type, which give a large, free opening for the admission of air to the cylinders, thus insuring a full volume under maximum speed. By simply taking off bonnets on the end of the valve seats the inlet valves may be removed without disturbing the valve gear. Air outlet valves are made of special steel, very light in construction, and work vertically with very light springs. The valve seats are also of steel, and are ground in place, and can be easily replaced when worn. The intercooler is placed in the base of the machine, and is similar in construction to a surface condenser. Water circulates through a series of small pipes, around which the air passes on its way from the low pressure to the high pressure cylinder. The cooling surface is very liberal, as is the space through which the air passes, so that the air moves slowly and has time to depart with its heat. By taking off a cap at the end of the intercooler all the pipes can be removed if necessary. For the main bearings, crank pins, crosshead pins, crosshead slides and eccentric straps a most efficient bath lubrication is provided. Sufficient oil is carried in the crank cases, so that the crank discs dip into it about one inch. As the discs revolve the oil is carried to the top of the crank cases, where it is scraped off the discs by copper spouts, which lead the oil into pockets near the top of the oil shield. From these pockets pipes lead to all the principal bearings. After running through the bearings the oil drains back again to the crank case, so that the operation of the system is continuous. This method of oiling has advantages over any other now in use. Even when

the machine is running as slow as eight or ten revolutions per minute sufficient oil is carried up by the discs, so that small streams are supplied to the different bearings. An oiling system dependent upon centrifugal force to carry up the oil would probably not operate at less than 150 to 200 revolutions per minute. This system is also more positive than a pump, which is quite apt to become clogged if the oil becomes thickened or there is any grit or foreign matter in it. Efficient oil guards are provided, so that no oil is thrown on surrounding objects or allowed to drizzle down the side of the engine frame. As all bearings are practically dust proof, and the working parts of the machine enclosed, the oil can be used over and over again, thus making a large saving, which often amounts to 5 per cent. per annum on the cost of the machinery. It has been found by experience that the friction loss is very much less when engines are provided with the bath system of lubrication. The amount of attention required by the engineer is also very much less, as there are no oil cups to be refilled.—*Age of Steel.*

Indicator Problems.

Every engine is capable of exerting more or less power, but with varying economy. With a constant speed and steam pressure there will be a point of cut-off at which the highest economy will be realized. The speed of an engine under ordinary conditions is fixed, and it is not usually the province of the ordinary engineer to vary it.

With the steam pressure it is usually different, in cases where the boilers are not working under a small margin of safety, and a careful, intelligent use of the indicator will often suggest variations that will result in a large saving of coal.

For instance, let us consider the diagram represented in Fig. 1. In the head end diagram we find the cut-off so early that the expansion line crosses the atmospheric, forming a loop, which indicates very wasteful conditions. The area of this loop not only must be deducted from the body of the card, but a careful consideration will show that such a marked reduction in pressure will result in a great loss of heat in the cylinder, and also a considerable condensation when steam is admitted for the return stroke.

With both diagrams from this engine alike, a reduction of steam pressure, to such an extent that the loop would be eliminated, would be a measure of economy.

In the crank end diagram we find existing conditions exactly opposite to those we have just considered, and but little less wasteful. In this case an increase of boiler pressure would be well worth a trial, provided the boiler were capable of safely carrying the higher pressure.

We have assumed that the crank and head end diagrams were taken from different engines, but it is safe to say that fully 15 per cent. of the engines now in operation in this country are laboring under an adjustment just as faulty as shown in Fig. 1, and the "mammy-daddy" exhausts we hear on the roofs of some of the largest mills bear evidence of the fact that even without an indicator changes would be made that would prove beneficial.

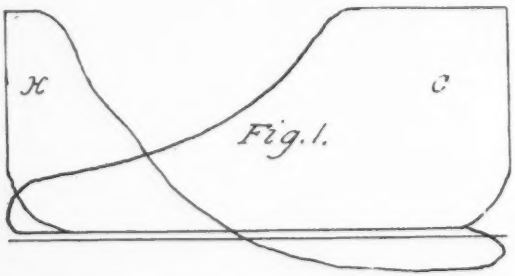


Fig. 1.

It requires no knowledge of the subject to see plainly that one end of this engine

is underloaded, while the other is overloaded to a wasteful degree, and no excuse can be offered for such a condition. We are compelled to think that in no place does there exist such a "penny wise and pound foolish" policy as in the management of some of these large plants. The engineer knows well the value of the indicator, but cannot convince the "powers that be" of its great utility. He certainly does not appreciate the idea of buying one to save coal for some one else, so there the matter stands.

In the meantime, the management will be using the backs of old envelopes for memorandums to save three cents worth of waste paper in a week.

In Fig. 2 we have another example of the way at least one engine is running.

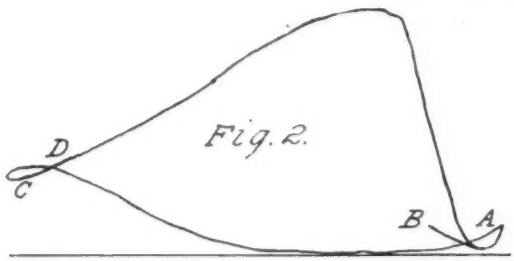


Fig. 2.

This is another case of misplaced eccentric. At A, as the piston nears the end of its stroke, there is evidence of a slight compression. As the motion of the piston is reversed the pressure almost instantly falls, until at the point B steam is admited, but too late in the stroke for the full pressure to be realized, as the piston is moving at too great a speed for this to be possible. The expansion is about as would be expected.

At C a peculiar loop will be noticed. This is caused by the failure of the exhaust valve to open until the point D, which caused the slight increase in pressure. When the valve did open, the piston was moving too fast for release of the exhaust steam, until at about mid-stroke.

In this diagram it will be necessary to advance the eccentric on the shaft about 40 degrees, when a good diagram would result.

In Fig. 3 we have an example of a different nature. This diagram was not the result of a faulty adjustment, but an accident. It will be seen that the effective area of the crank end diagram is almost equalled by the negative area of the head end, and the engine is not capable of doing much work. Rather the crank end is exerting considerable power to maintain a vacuum in the head end.

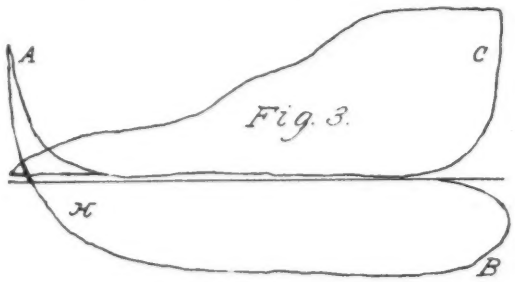


Fig. 3.

The explanation of this card is simple. In some way the steam valve stem became twisted so that the valve did not open on the head end. Whatever leakage existed in the cylinder was compressed to the point A, but as the motion of the piston was reversed this pressure would be instantly reduced, not only to atmos-

phere, but almost to absolute vacuum, and would remain at this pressure until the point of release, B. While this seems a serious case, a little thought will show that it is not so much so as the little leaks, so insidious as to be scarcely noticed, and the engine is allowed to run on, giving unsteady power and a greater consumption of coal possible for years. In Fig. 3, however, the trouble was apparent that the engine would not run at all, consequently they were compelled to order repairs at once, so nothing was wasted but a little time.

The use of the indicator is not confined to the steam cylinder of the engine. No more instructive or profitable operation can be performed than its application to the steam pipe or steam chest.

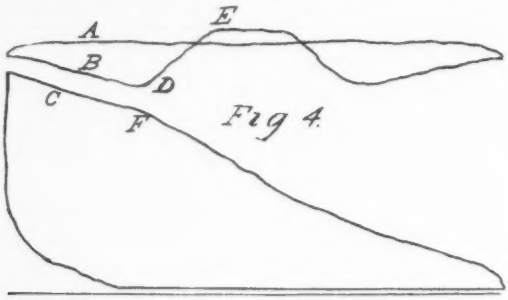


Fig 4.

In Fig. 4 a "steam pipe" diagram is presented, and it will be noticed that every fluctuation in pressure is accurately portrayed, and from this diagram we can determine to a nicety what proportion of the "wire-drawing" is to be attributed to insufficient steam pipe area, as well as the effect of defective valve action or inadequate port area.

The following diagrams, taken from those in the writer's practice, are so pointed and striking that a vast amount of information may be obtained from a careful examination of them in detail.

They were taken from an 18-inch by 48-inch old style horizontal Corliss engine, running 50 revolutions per minute, the piston speed being 400 feet, furnishing part of the power for a rolling mill.

Of course the power required varied very much; at times the full power would be required, at others scarcely anything. The boilers being old, only a moderate pressure of steam could be used.

Fig. 5 was the first card that had been taken in a number of years, the engine was one of a pair that had been used previously as auxiliary power, in a mill where they had water power sufficient to run most of the time.

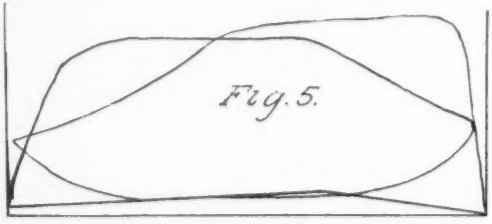


Fig. 5.

The two engines were in about the same condition, and were run side by side in the rolling mill, but were not connected, as each run separate trains of rolls, and in opposite directions. The exhaust from each engine ran into the same exhaust pipe, which operated unfavorably, which will be explained later on.

Fig. 6 shows a card taken after the valve seats had been bored out, valves turned, refitted and properly set.

What are the especially bad features, as shown on card 5? Too late! is plainly indicated in all the movements of the valves. The Corliss engine is known (by those familiar with steam machinery) as a four-valve engine, controlled by one eccentric (the old style is referred to); the steam valves are detachable by means of an "automatic cut-off" controlled by the governor. The steam valve on the crank end did not open until the piston had traveled one-fifth, or about nine inches, of its stroke; the other end was not quite so bad, the steam valve opening at one-tenth, or about five inches of the stroke.

What is the effect of this tardiness? The steam could not get into the cylinder until the best time for efficient service had passed and the effect of the most favorable opportunity for expansion had gone by and lost. By making the correction in steam time, as shown in card, Fig. 6, the line is seen to rise perpendicular to the point of initial pressure at the beginning of the stroke, and runs horizontal to the point of cut-off that expands gradually to the terminal pressure at the end of stroke, producing the full effect due to the regular diminishing pressure and expansion of the steam.

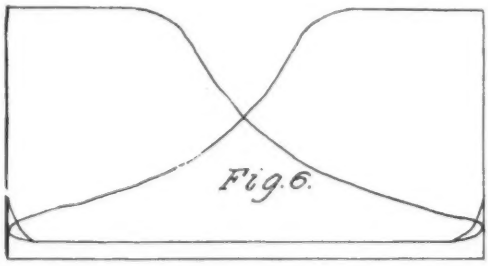
The next point of difficulty in card 5 is the late opening and closing of exhaust valves, which give the heavy compression at the terminal of the stroke at each end, and the lack of compression of the exhaust to meet the direct steam at the end of the stroke, upon the piston, thus avoiding unnecessary shock and pound.

There is another difficulty which seems appropriate to mention here in reference to card 5. There is a serious leak in the exhaust valves, as shown very strikingly at the hump, as seen in the line of the exhaust.

The average back pressure is about double that shown in card 6, the valves, as shown in that card being now tight and properly set, the exhaust line is straight from the terminal to the admission of direct steam.

Allusion was made previously to the exhaust from both engines being made into the same pipe, which, being too small, cramps the exhaust of both, and in the case of card 6, if that engine had been provided with a separate exhaust pipe, there would have been but very little back pressure.

Those who are familiar with the various types of automatic cut-off engines understand that the Corliss style is what is termed a drop-motion cut-off—that is, steam having followed the piston at very nearly the initial pressure, thus producing practically a horizontal line to the point of cut-off. The expansion then commences immediately, and gradually produces the hyperbolic curve or expansion to the terminal, as shown in Fig. 6. —*The National Engineer.*



Compressed Air for Machine Tools.

The increasing use of compressed air in connection with the employment of pneumatic tools and for other purposes has been the means of reviving the interest taken in the question of production and application of compressed air for power purposes.

In the case of the transmission of power by water pressure the power given off by a motor cannot exceed the product of the

pressure multiplied by the volume of water used.

With air, however—an elastic fluid—when used expansively, the power can be, and generally is, greater than the product of pressure and volume, the pressure and volume being those in the supply mains. Again, the work done against friction in forcing air through the mains is not altogether lost, as the heating effect due to friction tends to reduce the cooling effect due to expansion. Notwithstanding this, it is advisable to make the mains carrying the air as large as practicable, in order that the loss of pressure shall be small. For economy, especially in the larger type of compressed air motors, there is a considerable advantage in heating the air before being used in the motor; but in the case of small pneumatic tools it is probably hardly worth doing.

With reference to the best form of compressor to be used, it may be stated generally that for pressure above 70 pounds to 80 pounds per square inch it is advisable to compress in two stages—that is, the air at atmospheric pressure is drawn in and compressed to an intermediate pressure in the first cylinder, and from this it passes to the second cylinder, where it is compressed to the final or working pressure. Moreover, it is important that the air supplied to the compressor should be as cold as possible, and if there is any convenient and economical method at hand for cooling is so much the better, since the colder the air the greater the output of the compressor; further, it is very important, especially for the smaller class of drills and motors having a number of small pistons and valves, that the air should be as free as possible from dust and grit, to prevent damage from cutting to the numerous moving parts. As to the cooling of the air during compression, no doubt for those smaller pneumatic tools which have to be held in the hand during operation, it is advisable to cool by means of a water jacket surrounding the air cylinder, and not by injecting a spray of water into the cylinder. The latter is a very efficient means of absorbing the heat which is generated during compression, but the air leaves the cylinder in a more or less saturated condition. When this saturated air expands at the exhaust apertures of the tool, heat is absorbed, and the cold produced frequently forms ice in the exhaust passages and outlet, where the expansion takes place. This may be avoided by heating the air before it enters the tool, as previously pointed out, but in small plants this is seldom done, and hence it is advisable to keep the air as dry as possible.

The capacity of the compressor should be amply large for the work it has to do, since it is not economical to run it at high speed. Again, the clearance spaces should be as small as possible, especially if the pressure is at all high, and only one cylinder is used to produce the pressure. If injection spray is used, relief valves should be fitted, or water may accumulate and the cylinder end be knocked out. For riveting, a pressure of 100 pounds to 120 pounds per square inch is desirable for good work, but for drilling less pressure could be adopted.

Moreover, the question of keeping the pressure up to its maximum is very important, as bad work can easily be turned out by a good tool if the pressure is allowed to drop, and further, a reservoir of good capacity is of considerable service in keeping the pressure steady.

As to the consumption of air by the various pneumatic tools now on the market, it appears that for a given amount of work it varies as much as 25 per cent. among the different types, a result probably due in a great measure to the different degrees of air expansion allowed in the various tools.

A valuable feature in connection with any installation of compressed air is the absence of the necessity for providing exhaust pipes, the exhaust air being rather an advantage than otherwise, especially in the case of mines and quarries, and none the less in shops with a vitiated atmosphere.

Compressed air has been applied with considerable success as a motive power for tramways. In this case a storage cylinder is employed in which the air is stored at a considerable pressure and of sufficient volume to last for a complete journey of the tram car, and when exhausted is refilled with air at the pressure stations. Here, again, the exhaust is delivered freely into the streets and creates no nuisance, which cannot be said of many of the motor cars, which exhaust their burnt products of petroleum or spirits behind them.

For many purposes there is no doubt that compressed air has much to com-

mend it, not only ecoonmically, but hygienically.—*The Practical Engineer.*

Air Lift Pump.

Some time ago we gave a description of an air lift pump installation erected at Hyde Park Court Mansions by C. Isler & Co. We have recently, through the courtesy of Mr. William Morris, had an opportunity of witnessing the working of a much larger plant of the same description, which was employed in testing a new bore hole just completed by this firm for the Kent Water Company. A noteworthy circumstance in connection with this plant is the speed with which it was put to work. It was prepared, carried to the site, erected and started in about a fortnight.

The bore hole which was being tested was of the following dimensions: There was a well 25 feet in depth, lined throughout with a cast iron cylinder. This went down about 1 foot into the chalk, and from here to a depth of 82 feet there was a lining of 24 inches cast iron pipes, with shrunk collars and counter shrunk bolts. The bore hole was continued below this with a 23½ inch chisel to a total depth of 251 feet 3 inches. The 24-inch pipe stood up 2 feet into the bottom of the 6-foot well, and the bottom of the well was filled up to the level of the top of the 24-inch pipe with concrete. Although not fixed at the date of our visit, there was on the site and ready to be put in place on the top of this bed of concrete a disc of cast iron some 2 inches thick, with a central hole some 24 inches in diameter. The water rose to within about 5 feet of the surface when standing and sank to a depth of between 28 feet and 30 feet when pumping was going on.

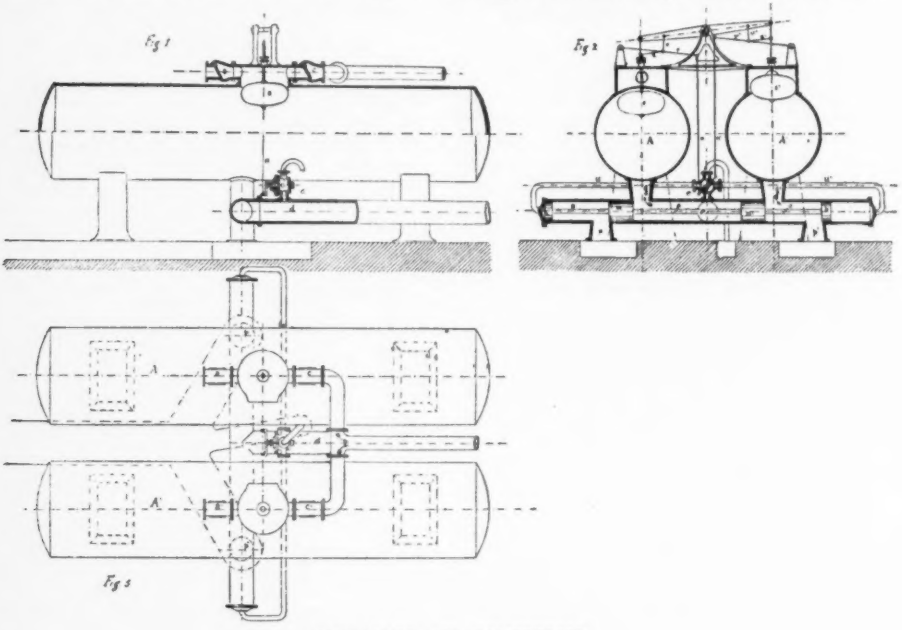
The apparatus used in testing the output of this bore hole consisted of a portable engine of 25 horse-power, nominal. A connection was taken off from the boiler of this to the air compressor, but as there was no injector it was necessary to occasionally run the engine of the portable so as to supply the boiler with water. This, of course, was only because the plant was of a temporary and makeshift character, and was highly inefficient, for the engine, being large, naturally absorbed far more energy than would be necessary to simply feed the boiler. The compressor used was of the horizontal two-flywheel type, with the steam and air cylinders arranged tandem. The steam pressure was kept at from 78 pounds to 82 pounds on the square inch. The diameter of both air and steam cylinders was 14 inches and the stroke 16 inches. The compressor was constructed to run at 100 to 120 revolutions a minute. It delivered air into a reservoir constructed of an old corrugated boiler furnace flue, with ends riveted to it, and a connection from this was led to the bore hole. Dipping down into the 24-inch bore hole to a depth of 123 feet from the surface was a 7¼-inch rising main. Running down beside it was a 3-inch pipe coming from the air receiver. The bottom of the 7¼-inch pipe was widened out to 8½ inches internal diameter, and by means of two right-angled bands the 3-inch air pipe was turned up into this, projected upward some 2 feet 8 inches from the bottom of the rising main. This was the whole of the apparatus. The rising main delivered into a tank at a height of some 4 feet from the ground level, so that the total lift when we saw the plant at work was about 34 feet. At the end of the delivery tank, away from the inlet from the rising main, there was a rectangular notch exactly a foot wide. As observed by us at a point taken as far back from the weir as possible, the height of water above the sill of the weir was 9¾ inches. According to Molesworth's tables, this is equal to 156.7 cubic feet per minute—say, 1,400,000 gallons per hour. The air pressure in the receiver started at 50 pounds, and decreased while pumping was going on to 30 pounds, at which it kept constant.

Mr. Gerald Morris, son of Mr. William Morris, the chief engineer of the Kent Water Company, has kindly put at our service the details of a rough test he made with this plant when working similarly to when we saw it. The quantity of water lifted was in this instance at the rate of 1,350,000 gallons a day of 24 hours. During a trial lasting 8 hours 20 minutes 14 cwt. of coke was burnt. The actual efficiency arrived at from the compressor to the water pumped was 25½ per cent. The method adopted in arriving at these figures was to take the mean between the pressures of atmospheric air and the air as delivered to the receiver, and multiply it by the length of stroke, the area of the compressor, and the number of revolu-

tions. The possible efficiency of a pump of this class is not high, but the particular value of the system, as well shown in the present instance, is its adaptability, and the absence of working parts in the well itself. Practically everything is above ground and easy to get at should it go wrong.—*The Engineer*, London.

A Simple Hydraulic Air Compressor.

Mr. Ernesto Ferraris writes as follows in the *Engineering and Mining Journal*:



HYDRAULIC AIR COMPRESSOR.

"In 1876 I constructed at Monteponi, in Sardinia, an air compressor which utilized a waterfall of about 30 m., the air being used to operate a number of Burleigh drills. This compressor worked for two years with very good results, supplying dry air at a uniform pressure. In 1887 I took up the idea again, with the intention of obtaining patents and utilizing the system in ventilating mines or in the construction of tunnels. Not finding use for the patent within a short time, I allowed it to lapse. I hope, however, that this construction may interest your readers, and I send therefore the accompanying drawings, which show a longitudinal section, a cross section, and a plan of the installation. I believe that it will be found a simple and efficient machine. The apparatus is composed of two boilers or cylinders, into which alternately water under pressure enters from above, compresses the air contained in the cylinders, and forces the compressed air into a pipe placed above. When one cylinder has been filled with water, the water is discharged automatically, while free air enters to take the place of the water and to prepare for a new action of the apparatus. The distribution of the water is regulated by two floats, which move in the domes placed on the cylinders. These floats are connected by a balance lever and by two rods, which pass through stuffing boxes on the domes. A Watt parallelogram guides the rods, while the two levers, V.V¹, Fig. 1, carry two vertical rods, Y Y¹, which are arranged to operate a four-way

valve placed on the compressed air pipe. This pipe, a^1 (Figs. 2 and 3) leads the water into a transverse pipe, *r* (Fig. 1), which joins the two cylinders below by means of the connections $g\,g^1$. Four pistons, *h*, *l*, *m* and *n*, are placed on one piston rod, which moves in the pipe *a* on the right, and a^1 on the left serving to open the air inlet into one cylinder, while at the same time they permit the flow of water from the other by the connections $g\,g^1$, and by the lower openings, *p*, *q*, into the free air. To move the rigid system of four pistons to the right or left, as required, and to stop the motion of one of the ports which close from the two sides of the tube t^1, the two extremities are connected by pipes with the two lateral branches of the four-way valve. In this way one end of the distributing pipe *f* is placed in communication with the free air, while the other communicates with the air under pressure. When one cylinder is full of water, and the water from the other has run out, the float in the first one will be raised, and its movement will cause the parallelogram to move also, and the latter will give a quarter turn to the four-way valve. The communications with the distributing tube being thus inverted, the system of four pistons will be forced in the opposite direction, and the water under pressure can then enter the empty cylinder, while the water in the other cylinder escapes. Air will enter into this cylinder by the upper air valve, and the compressed air will pass through the pressure valve *c* of the other cylinder, and will pass off through the conduit *b*. This system is very simple. It presents no dead points, and very little loss by friction. It will compress the air to a point almost equal to the pressure or head of water available. This large surface of water absorbs the heat evolved in compressing the air, so that it is not necessary to cool the valves. It can be used for ventilating purposes only, to supply air for drills, or for the distribution of power. In a mountainous country, where water powers are available, it will be found exceedingly useful. This air compressor will work with very little attendance or supervision, and is very cheaply operated. Moreover, the first cost of the installation is low, since it replaces the reservoirs for compressed air required in other plants; while no expensive buildings nor foundations are needed.

Cleaning Iron with the Sand Blast.

The writer has been interested in the sand blasting and painting by the bridge department of the Boston & Maine of a large overhead truss iron bridge across the Merrimac River at Lawrence, Mass. This bridge is nearly 900 feet long, and, like most of its class, after long exposure it was badly rusted; but the sand blast cleans it of old paint and rust at the rate of about one square foot per minute. If desired to make the cleaning more thorough, the nozzle of the blast is held nearer the work—within a few inches—when it leaves it as devoid of paint and rust, apparently, as a new silver dollar. Held off a foot or two, it does good work. It appears to be the ideal way to prepare the surface of iron bridges, or, for that matter, any rusted iron surface for repainting. A gasoline engine and compressor combined is installed near the bridge, with the requisite reservoir for the air, and tanks of water for dripping on parts of the engine to keep it cool. This engine, once started in the morning, requires no one to remain with it to tend it, and uses about fifteen gallons of gasoline daily. Near the work are tanks of beach sand, from which large hose with suitable nozzles lead to the work, and thus is blown upon the iron at about 16 or 17 pounds pressure, a large iron pipe conveying the compressed air out on the bridge where wanted. Six men began this bridge the first of May, which was a rainy month, only about a week of it being available for outdoor work of this character, and they had it about completed July 23d. Time enough is taken to paint before night that which has been cleaned during the day, so that it shall not again get rusty with the dew falling; and for this purpose they were using with brushes (air painting not being practical for this purpose) Dixon's Graphite Paint, and if some sand gets into the undried paint no attention is paid to it, as this is found to be not detrimental. This has now become the standard method of treating iron bridges on the B. & M., and when one is completed the crew receives orders to proceed to another, perhaps in another State, whither they go with their apparatus loaded, and with their boarding car, where the men eat and sleep, a cook accompanying them to take care of their needs in this regard.

This may at first thought seem an expensive process, but doubtless the excellent results obtained more than compensate for the outlay. It should be said that this work is not carried on in the winter months, as freezing weather is not only not conducive to the best results in painting exposed iron surfaces, but it would also be fatal to the successful working of the apparatus where water and condensation from the compression of the air form an unavoidable part.

Railways will doubtless do well to look into this matter of preparing the iron surfaces of tanks and bridges for paint in this way, if they have not done so already. —*Railroad Digest.*

The Baldwin Acetylene Mine Lamps.

We show herewith cut of a lamp now being successfully introduced for lighting in underground workings. The lamp here described is mostly used in connection with rock and coal cutting machinery, for station lamps, and to light large chambers. Other sizes are also made for mining purposes, but not illustrated in this article.

This lamp is made of cast iron, 6 inches high by 6 inches in diameter, and weighs 12 pounds. It is opened in the middle, by loosening the thumb screws. Into the bottom is poured one pound of a specially prepared carbide, the top being replaced and firmly closed; is filled with water, and the lamp burns at once. The lamp requires almost no attention while burning, which by changing the amount of carbide can be filled to burn for 6, 8, 10 or 12 consecutive hours, as desired.

The special advantages of these lamps are their great economy and beautiful light. Light for light, acetylene gas is far cheaper than electricity, oil, or candles; the light resembles sunlight, and moreover is absolutely free from smoke or smell.

With regard to the cost, the lamp here shown uses a ½ foot burner, consuming one pound of carbide in eight hours, giving a light almost equal to two 16 candle power electric lights. This carbide costs in 100 lbs. drums, 5 cents per pound, at Niagara Falls. With freight added, the cost is about 6 cents per lb. at the mines, that is, a light almost equal to two electric lights, at a cost of 6 cents for eight hours.

A smaller lamp is made, giving as much light as three oil lamps, or six candles, which consumes ½ lb. in eight hours, and smaller lamps are under construction,

THE BALDWIN ACETYLENE MINE LAMP.

which will cost only 1½ cents for eight hours' burning.

These lamps have been fully tested during the past year, and have demonstrated their practicability and economy. They

are in use now in many mines, and are extensively adopted by the contractors of the New York subway, as from their construction, they are virtually indestructible, and are the lamps that have proved most suitable for their severe usage.

Air Versus Water.

BY JOHN F. O'ROURKE, M. AM. SOC. C. E.

* * * There is a general impression that what is known as a quicksand possesses certain mobile qualities which cause it to flow and from which it derives all its dangerous characteristics. Such a thing as a quicksand proper does not exist. Quicksand is simply sand surcharged with water, the tendency of the water being to flow to a lower level when unconfined, the sand flowing with it, so that the quicksand is really sand and water mixed, and this same sand without the water possesses no fluidity whatever and differs in nothing but fineness from ordinary sand. It can be said that all sand is quicksand if the head of water is sufficient to cause a flow. * * * It being clear, then, that quicksand is merely a consequence of the water upon sand, it is plain that in any devices that may be adopted to deal with the difficulties that may be encountered in operations involving excavation in such material, it is the water and not the sand which we have to fight. The function of tongue and grooved sheet-piling is to prevent the flow of water through the sides of an excavation; but, as we have seen, a point may be reached when the water will flow under the sheet-piling, bringing the sand with it as fast as it can be taken out. Other methods are employed, such as freezing, sinking drive wells in the ground to lower the water level—anything to get rid of the action of the water. These methods have all their limitations, and the one great and practically certain means of penetrating below the water level is the use of compressed air, which brings us to the title of our lecture.

The use of compressed air is limited to pressures of about 50 pounds to the square inch, since man cannot work under a higher pressure than that for any period of time which would be practical, which limits the immersion to about 110 feet. Where foundations have to be taken down deeper than that still, other means must be resorted to, as in the case of the Poughkeepsie bridge, where 130 feet below water was reached by means of large cribs through which the material underneath was excavated by dredging, and which when undermined in that way were finally landed on hard bottom. It is sufficient to say now that, after compressed-air limits are reached, there are other means of accomplishing the work—"Machinery against Water," a most fascinating subject to go into, but which we must deny ourselves at this time. In most cases, however, air is sufficient for the purpose sought, and very few engineering operations are likely to be undertaken where the use of air is not sufficient for the purpose.

Pneumatic caissons were first used for founding the piers of bridges, but as modern developments in buildings brought them to great heights, concentrating great loads on their foundations, pneumatic caissons have become quite common under them, wherever the soil beneath was unstable for a depth, requiring the use of compressed air to penetrate. The general principles of design and operation are the same for bridges and buildings, the difference in sinking caissons in the latter case being largely due to the greater care required because of the danger to adjoining streets and buildings, and the difficulties involved in the smaller size and the higher loading per square foot of base permitted and employed. Excavation to water level is usually done in caissons before the air is turned on, and one has a chance to see the quicksand act just as it is entered. At that time the bottom is a mire into which the men sink half to the knees, and sometimes have to be pulled out of their boots before they can move. Fifteen minutes after the compressed air has been turned on this same material is dry and firm, and however fast the caisson goes down, it is not likely that water will be seen again; * * * what was a quicksand before is now a dry, fine sand, with a plentiful proportion of mica, one of the most favorable materials existing in which to excavate.

The operation of sinking the caissons usually consists of digging in the middle of the air chamber, working the hole out

* From a lecture delivered before the College of Civil Engineering of Cornell University and printed in the Transactions of the Association of Civil Engineers of Cornell University.

toward the cutting edge until the support under the latter is weakened and the caisson drops of its own weight into the hole so prepared. This hole is inside the outside line of the caisson, which thus cuts a hole of its own size as it goes down and takes the place of the excavated material in sustaining the adjoining earth and buildings. After a caisson has been carried down for a considerable distance, it is very difficult to pile on enough ballast to make it follow down with the excavation, so that it is common to release the air pressure for a fraction of a minute, during which time the caisson falls as far as the excavation beneath allows, which sometimes is as much as 5 feet. The operation is not always dangerous when it is done quickly and the caisson is of sufficient strength to stand the new pressures that immediately act when the air pressure is removed from within, but one can readily imagine very serious consequences if attempted otherwise, or by people who are not able to judge when it is safe to try it. As a consequence, most specifications for pneumatic caisson work have a clause which forbids "blowing off the caisson," which has one very important result—that is, if a contractor meets with disaster in doing so, the engineers can say, with great justice, that if he had followed the specifications, nothing of the sort would have happened.

Passing from the general subject and coming down to particulars, I will quickly run over three or four works where caissons were used, and give you some idea of both the caissons and the work itself.

We will first take up the caissons of the Gillender building, as they are what might be called transitionary, being built identical in design and structure with those used for bridges. These caissons are about 25 feet in length and 12 feet wide in the case of the two outer ones and 15 feet for the other, and they extend about 50 feet below the curb. They are built of heavy timber walls in the air chamber, the cofferdam above the air chamber being made of planking, with brick piers resting upon the roof of the air chamber the entire size of the space inside the cofferdam. The sinking of these caissons was accomplished without any particular difficulty, the trouble arising after the caissons were sunk in getting the cantilevers in place; the material was found to be a very lively quicksand, and more time and expense were involved in getting the excavation made for them which was larger than the caissons, and was done with the aid of sheet-piling driven by a piledriver, than the caisson work itself cost. The adjoining buildings were supported on 16-inch steel cylinders, sunk to the hardpan by means of jets and hydraulic jacks, the interior being afterward filled with concrete. In placing this concrete, a small dumping bucket was used, which allowed the concrete to escape to the bottom, when bottom was reached. But this acted so much like a piston and seemed to scour the cement so greatly that we devised a much simpler way of doing it, which was to put the concrete in paper bags and dropping them into the pipe, which was filled with water. The paper bag held together until it reached bottom, when it broke. There was a gush of air through the water and that was all, the cement not appearing on the surface in anything more than a trace.

The next building we will take up is the Sohmer building, on Fifth avenue and Twenty-second street. Nine of the caissons here were made of wood, as in the case of the Gillender building, and five were of steel, cylindrical in form. * * * The 14 caissons were sunk in 27 days, which at the time was considered a very rapid operation.

The next work we will turn to is the foundations for a residence built by Mrs. Elliot F. Shepard on East Sixty-second street, where caissons were necessary because of the site having been formerly an old pond which was filled in with rock, the ground underneath the rock being mud and clay, and through which the caissons were all taken to solid rock, about 50 feet below the curb. The problem presented to me for this building by the architect was that some means should be found for reducing the cost of pneumatic caisson work, as his client did not feel disposed to go in for any such expense as the ordinary steel caissons would cost. The caissons for the Sohmer building were some of them steel and some of them of wood, and as no advantage was found in the case of steel, after much thought on the subject, I devised the wooden stave caissons, which since have been used with so much success. The ground, as I have already told you, had been filled with rock through the water,

and as a result a great deal of blasting was resorted to in these caissons. One caisson had in the neighborhood of 40 blasts fired in it, each hole being charged with half a stick of dynamite, and the pieces of rock that were thrown against the sides in some cases weighed 200 to 300 pounds. The only effect they produced was a light indentation, less than a half inch in depth, the ground outside and around the caisson backing up the timber in such a manner that the 3½-inch thickness of wood offered as effective a resistance as if it had been 3½ feet.

The next building is the McCready building on the corner of Twenty-first street and Fifth avenue. Here the conditions involved were very difficult. A building about 50 feet in frontage, 100 feet deep, and 10 stories in height had been erected upon a clay bottom that was of such a yielding character that there was a comparatively uniform settlement of the old building amounting to several inches. The owners of the building, who were also the owners of the adjoining corner lot of similar size, desired to extend the building so as to have a new building of twice the size and so designed as to conform to the one already built in such a manner as to make it appear like one large building. It was at first intended to build upon footings of concrete and steel beams, or, as it is called, "to float the building;" but this was finally abandoned, and I was given the contract to put in pneumatic caissons. They were all ready to go on with building operations when they came to this conclusion, and as a result great haste was necessary in order to have the building ready on time, as the greater part of the floors had already been rented. I was informed of the acceptance of my bid one evening about five o'clock by telephone, and the next morning teams were already hauling the plant there. Three days after receiving the order enough material for several caissons had been delivered at the lumber yard, the staves were already dressed, and in about a week after receipt of the order the plant had been erected, and the first caisson was on the ground and being sunk. This would not have been possible if steel caissons had to be used. * * *

The caissons that abutted on the adjoining buildings were made with the cutting edge oblique to the axis, the deeper side being set against the adjoining building and the escaping air coming up under the high edge away from it and not disturbing the foundations. This was especially important because of the manner in which this adjoining building had been constructed and the serious difficulties that would have been encountered had shoring been resorted to.

The last case in which these caissons were used was at the Atlantic Mutual Insurance Company building, on the southwest corner of Wall and William streets. This building required 42 caissons, and the adjoining buildings were on a very treacherous quicksand. * * * It was considered a very risky operation to put them down without first supporting the adjoining buildings on cylinders, and I was not encouraged by people familiar with sinking pneumatic caissons under such conditions, none of them having ever done work that way. As a matter of fact, without any exception whatever that I am aware of, all expected trouble. No trouble followed. The caissons next to the adjoining walls were built with a greater amount of obliquity of cutting edge than ever before, the larger caissons having a difference of level between the inner and outer sides of 14 inches, and the caissons themselves were made stronger than any heretofore built. The amount of grease with which the staves were lubricated was as great as they could be made to bear.

The real test was with the caisson adjoining the front corner of the ten-story granite building of the United States Trust Company, the first caisson sunk against the adjoining walls. It required twice as much ballast to sink it as similar caissons with the cutting edge at right angles to the axis. Again, the ground all around the caisson was perfectly hard, as shown by testing it with the bar, except at a point in front of the highest cutting edge, which was so soft that the bar could be pushed in its full length, due to the escaping compressed air churning of the water in the ground there. The most satisfactory demonstration of all—that it could be safely done—was, however, in the fact that there was never the least appearance of disturbance of foundations discovered in the adjoining building. * * * I was so satisfied of the certainty of the means employed to produce the desired results that at 10.30 p. m. on June 26, half an hour after the air had

been turned on in this caisson, things were going so smoothly and rapidly that I went home to a good night's sleep. When I reached there next morning, about six o'clock, the caisson was more than 20 feet below the foundations of the adjoining building, which remained unmoved. * * *

The third and latest work of this sort is for the New York Stock Exchange building (George B. Post, Esq., architect), the work of which will be begun after the building has been torn down. The contract for doing that work has been made with me, and I have devised an entirely novel method for carrying it out. This property is 21,000 square feet, about one-third larger than the Mutual Life Insurance Company's work, and the immersion will be about 42 feet, or three times that of the Commercial Cable building. It is interesting to see that we are advancing in terms of 14 feet in our immersions. First, the Commercial Cable building, with 14 feet; then the Mutual Life Insurance Company, with twice 14 feet, followed by the New York Stock Exchange, with three times 14 feet. If the rule is not broken, the next job will have an immersion of 56 feet, and as solid rock will be the bottom there for the first time in the three, the water developments may encourage even greater depths.

I told the architect that I would make a continuous masonry dam. * * * My experience with circular wooden caissons, and also with the square wooden ones at Twenty-second street, made it plain that wood was the proper material to use. It is smoother, stronger within the limits in which steel would be employed, and more pliable in the sense that it can be adapted better to the desired uses; and a fact perhaps just as important as any, it is always within your command as to supply, which is not the case with steel. * * *

The caissons will be filled with concrete above the roof, with a well at each end of the caisson, the roof underneath being removable. The ends of the caissons where they abut on each other will be made removable in sections from the cutting edge to the top, by filling which with concrete masonry is made continuous.

Cooling Water by Compressed Air.

Cooling water by means of compressed air is an easy matter. The cold, expanded air should only be led through a pipe or coil of pipe dipped into the water to be cooled, and then exhausted into the atmosphere.

The writer can recall a fact of personal experience, when in charge of some tunnel work. A ventilator fan blowing fresh air to the front was actuated by a small steam engine working with compressed air, the exhaust of which was led into a closed chest containing tin tumblers filled with water. On its way to the discharge orifice the current of escaping air was passing along the row of tumblers, and some ten to fifteen pounds of ice were thus daily made quite readily. The miners felt interested in the progress of the refrigeration, and the men of the outgoing shift would seldom fail to dip a dusty finger into some of the tumblers, whose main peculiarity was the existence of a black core at the centre of the block of ice. When air at a given pressure and temperature is allowed to expand adiabatically too say atmospheric pressure, there is no theoretical difference between the volumes of the air, and consequently its temperature, at the moment when the lower pressure is reached. In practice the results are quite at variance.

The air which has done expansive work behind a piston moving in a cylinder escapes at a low temperature and at a moderate speed, and is fit for use as a refrigerating agent. Such is the principle applied in the Bell, Coleman and Allen air engines.

In the air which is simply released through a valve the whole expansive work is converted into velocity, and almost instantaneously transformed into heat by friction with the surrounding atmosphere or against the neighboring bodies. The result is that no cold can practically be produced in this manner.

Besides, the use of an expansion cylinder coupled to the compressing cylinder reduces to a minimum the actual amount of work required by this process of refrigeration. Its efficiency is low, and it is not economical on a large scale as compared with the ammonia process; but it possesses advantages of simplicity, of cheapness and of safety, which in many cases will make it quite valuable.—A. E. Chodzko, in *Mining and Scientific Press.*

Compressed Air in a Swedish Mine.

A mechanical rock-boring plant in Dannemora which has been in operation since 1891 includes a duplex air compressor of 90 indicated horse-power when running at its full speed, having been designed for ten rock drills, but it has hitherto been used for only four at the same time, so that, as the compressor running at about half speed only develops 40 horse-power, each rock drill absorbs 10 horse-power. The air compressed to 55 or 60 pounds per square inch above atmospheric pressure is led from the compressor into a plate-iron receiver of 13 cu. m. (459 cubic feet) capacity, freely exposed to the atmosphere, and from this receiver the air passes into cast-iron pipes of 15 c. m. (6 inches) diameter, 2.6 m. (8 feet 5 inches) long, and 17.5 mm. (11-16 inch) thick.

The line of pipes is partially covered with earth, and partially left uncovered where it passes over the mouths of some shafts, in which case it is protected by straw bands from too great cooling down and also from the formation of ice. As an additional precaution, the line of pipes falls slightly from each end toward the middle, where there is a downward bend fitted with a cock. If the moisture in the air be condensed, the water will run into this bend, from which it can be drawn off. The pipes are, however, sometimes frozen up, especially in spring, when the snow melts.

The principal working place in the mine is 215 m. (117 fath.) from the surface, and the compressed air is led thereto, first in 3-inch and afterward in 2-inch pipes. Each branch is fitted with a shut-off valve and provided with an india-rubber pipe, which is led to the workings, where the air is distributed by 1-inch pipes to three rock drills; but before the air arrives at the drill it is led through a wrought-iron coil, heated by a small charcoal furnace.

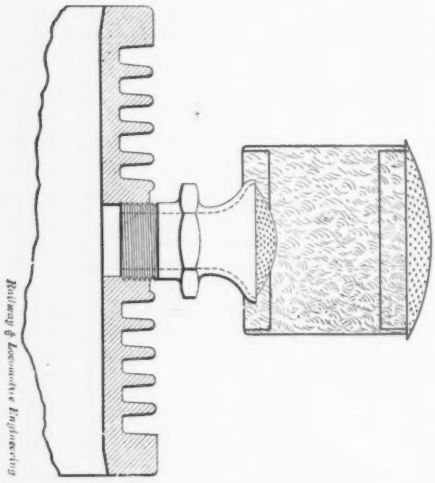
By these means the compressed air is warmed and its useful effect increased, while too great cooling down owing to the expansion is prevented—a most important matter—while the lubricant in the rock drill does not become hard and the temperature of the working place is not lowered. That this warming of the expanding air exerts a very favorable influence may readily be ascertained by putting out the furnace, when a considerable decrease of temperature will be noticed—at any rate, near the rock drill. At the same time, the compressed air must not be too highly heated, or the india-rubber pipe between the furnace and the rock drill will soon be injured. J. W. P.

Moral Effect of Compressed Air.

There is no error, printer's or otherwise, in this title, which conveys a correct idea of the excellencies, moral as well as physical, which M. F. Mathet, late chief engineer at the Blanzy colliery, attributed at the Saone et Loire congress of the Societe de L'Industrie Minerale to this agent for transmitting power. He contended that by supplementing the ventilation and superseding hard manual labor underground, compressed air induces such a higher state of well-being in the miner that it permits him to turn his leisure to better account by study and preparation for a better position. On resigning his post at Blanzy, which he had held for twenty years, M. Mathet was appointed consulting engineer of the colliery, and was at the same time elected honorary president of the Burgundy section of the above-named society of engineers. In returning thanks for this honor he mentioned the fact that there were then underground at Blanzy more than 250 machines and appliances driven by compressed air, of which at a pressure of 4.5 kilograms per square centimetre (64 lbs. per square inch), nearly three million cubic metres (105,949,700 feet) were sent into the workings every month. He concluded by observing that without ceasing to keep a watch on electricity, which may perhaps still have some great surprises in store for us, he had the fullest confidence in compressed air; but he hoped that manufacturing engineers would turn their attention to improving the appliances intended for its use, so as to insure a better yield, because the low useful effect was strongly insisted upon by its detractors, since there was little else that could be brought against this excellent method of power transmission. J. W. P.

Strainer for Air Pump.

Mr. I. F. Wallace writes: "I have seen several articles coming from men running engines on the desert sections of the West and Southwest complaining about their air pumps giving trouble from air cylinder overheating, caused by sand and dust having been sucked with the air into the cylinder. The illustration of air strainer for pump explains a simple device which obviates all this trouble. It will be seen that there is a casing of Russia iron sol-



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dered to the air strainer proper. This casing is filled with curled oiled hair. A perforated cap is made to slip inside the casing to keep the hair in place. When air passes through, the oiled hair catches all the dust and dirt, and it goes into the cylinder perfectly clean. When the hair gets full of dirt, take it out and wash it in coal oil, then re-oil with a little valve oil and use it again. This device has been in use here (Minneapolis, Minn.) for two years, and it works like a charm. Any tinsmith can make one and put it on in twenty minutes."—*Railway and Locomotive Engineering.*

Notes.

It is fair to figure that a three-inch rock drill, driven by compressed air and working at an altitude of 5,000 feet above sea level, will consume eight indicated horse power as developed in the air compressor. At an altitude of 10,000 feet the same size drill would consume about ten indicated horse power.

A neat standard size catalogue has been issued by the Empire Engine and Motor Company, of Orangeburg, N. Y. The pneumatic motor chain hoists, drills, reamers, center grinders, portable winches and hoisting engines are illustrated by half-tone and line engravings showing the tools in operation, as well as in the detailed reproduction of many sectional views. The pneumatically driven center grinder is quite a novelty; it fits any tool post and has provision for immediate and accurate adjustment to the regular angle for lathe center grinding.

The intense and long continued hot weather gives especial interest to a little arrangement devised by T. A. Foque, mechanical superintendent of the "Soo Line." It is a pneumatic fan, designed for use where electricity is not available and compressed air is. It works fully as well as an electric fan, and can be made at small expense. Mr. Foque has already furnished working drawings to some who have seen the fan in operation, and, we understand, is willing to extend the favor. The amount of air required to run it is very small and "never would be missed."

It has long been known that immense beds of salt underlie the coast of Louisiana, but they have been little worked hitherto because of the difficulty of reaching them. They are overlaid by a bed of quicksand, which has defied all efforts to keep it out of the workings. Now, it is said, a way has been found to control the quicksand by means of caissons filled with compressed air until substantial shafts can be built to the salt beds. If this is true, the world's supply of salt will be vastly increased, and the mineral wealth of the Southwest, already great, will be substantially augmented.

The largest solid piece of granite ever loosened in a quarry in this country was separated from its natural bed in the John L. Goss quarries, Crotch Island, Stonington, a few days ago. It was estimated to weigh 52,000 tons. This enormous mountain of granite is 325 feet long, 50 feet wide and 38 feet in depth. "This," says Mr. Goss, "is the largest piece of granite ever loosened in this country." Months of careful work were expended in loosening this giant piece of granite from the pyramid-like mountain where it rests. The peculiarity of the granite formation at Crotch Island alone makes this enorous piece of quarrying possible. The granite lies shelf on shelf, and, in order to separate one layer from the other it is necessary to drill hundreds of holes, into which dynamite is placed and fired.

Hoisting and conveying machinery has developed amazingly during recent years. Such equipments as are now offered by the manufacturers comprise about every design that industrial and manufacturing operations have suggested and made a demand for. The Lidgerwood Manufacturing Company, of 96 Liberty street, New York, has reached a most prominent position in the design and construction of the class of equipments referred to. This company has established an exhibit of its machinery at the Pan-American Exposition, but it is necessarily very incomplete, because of the limited space obtainable. The Lidgerwood apparatus is used all over the world, many special forms for special purposes having been installed. An illustrated booklet of the Lidgerwood exhibit at Buffalo has been issued. It is of interest to all present and prospective users of hoisting and conveying machinery of all kinds.

A process for producing glass vessels of an unusually large size, says Consul Hughes, of Coburg, has been discovered by Paul Sievert, of Dresden. The liquid glass metal is poured upon a cast-iron plate and runs as far as the overreaching edge of the plate, where it hardens. The still refractory glass metal frees itself from the plate—the hardened edge remaining fast—and forms an elongated sack, the bottom of which rests upon a table. By means of a hollow cylinder and a plate pierced with holes compressed air is conveyed to the sack, which, the table being lowered, is blown to the required size. The upper glass edge is then freed by the removal of the overreaching edge of the plate and the table continues to sink. The finished vessel is then allowed to cool. Previous to this time, the Consul adds, concave glass could be blown to a size of only 1 hectoliter (26.417 gal.), but with the above method bathtubs and large glass kettles can be made.

Those interested in the subject of cold storage by means of ice should be acquainted with the facts as set forth in "Natural Ice Cold Storage and the Cooper Systems of Refrigeration." This has been published in pamphlet form, accompanied by diagram drawings. Its contents include reference to the application of ice to cold storage purposes; the early patented systems, most of which have been abandoned; gravity brine circulation system and indirect circulation; the circulation of air in cold rooms and their proper ventilation, etc. The greater portion of the pamphlet appeared as a series of paid contributions to the oldest paper in the ice and refrigerating trades, which should vouch for its usefulness. The results which may be attained by the use of ice, as illustrated and described, are fully equal, and in some respects superior, to those obtained by the use of refrigerating machinery. The author, Madison Cooper, is refrigerating engineer and architect at Minneapolis, Minn. He will send the pamphlet for twelve cents in stamps.

The practice followed by Mr. H. Schaefer, Central of New England, of turning the exhaust steam from the air pump into the cylinder saddle, has effected material saving of steam, besides abating the nuisance of the noise of the steam exhausting from the air pump. This is the most practicable way of disposing of the exhaust from the air pump that we have seen, and is well worthy of imitation. We find officials of some roads very zealous in urging engimemen to do all in their power to save coal, and at the same time thev have the air pump exhaust pouring through the smokestack and fanning the fire in a way that wastes many tons of coal in the course of a year.

On some roads they are turning the exhaust from the air pump into the tender

to heat the feed water, but that is a troublesome arrangement. It happens occasionally that an engineer lets the water get too hot for the injector to lift, and then there is the report of an engine failure. One engine failure offsets in expense the saving effected by many days' use of a feed water heater.

A great deal is being made now of the recently discovered liquid air, and it is supposed that a good deal will be able to be done with it, such as expanding shot holes to get the coal down in place of using explosives. It is stated that liquid air is now being made at a comparatively low price. It should not be forgotten that liquid air is produced by the expenditure of a certain quantity of energy, and that it can only give up, in resuming its normal condition, the energy which has been expended in liquefying it, less the usual charges that are made in all cases of conversion from one form of energy to another by the apparatus that performs the operation. It may be useful in certain processes where expansion is required on account of its portability and its supposed safety, but many very awkward problems will arise in dealing with the very low temperatures and very high pressures. According to the accounts, it appears that the air remains liquid when once in that form, notwithstanding the removal of the pressure, and its exposure to a higher temperature. This at least appears to be doubtful. However, it is early yet to decide on what can be done.

In a recent issue of *Le Genie Civil* is published a short note describing a machine for increasing the oxygen content of air before using it in furnaces The machine is said to be due to M. Mazza, an Italian engineer, and is merely a centrifugal separator. On passing air into this centrifugal machine the oxygen molecules, being heavier than the nitrogen ones, tend, it is stated, to concentrate at the periphery of the machine, and on drawing off the air at this surface it is found to be considerably richer in oxygen than normal air. In fact, the oxygen content can, it is said, be readily brought up to 26 per cent. of the total. Common air, it will be remembered, contains but 23.2 parts by weight of oxygen. The centrifugal machine used acts at the same time as a blowing fan, the enriched air being delivered under a slight pressure, while the impoverished air is drawn off continuously from near the centre of the machine. About 2 horse-power are needed, it is stated, to operate a separator capable of delivering 18,000 cubic feet of enriched air per hour. This enriched air has been used for supplying the furnaces of a boiler, and has led, it is stated, to an increase of water evaporated per pound of coal from 9.5 pounds, with natural draft to over 12 pounds with the Mazza apparatus.

The oils hitherto used at the Alte-Dreisbach mine, in the Siegen mine inspection district of Germany, for lubricating the air compressor soon stopped up the passages and became deposited on the surface of the piston, forming a mass gradually increasing in hardness, and thus favoring explosions under certain circumstances; but this difficulty has been completely overcome through lubrication being effected by a mixture of soap and water in the proportion of 1 to 15. Since this change has been made a cleaning of the parts in the cylinder, etc., is only required every three months, and a simple washing is found to be sufficient for the purpose, all danger of explosion being now quite removed, whereas formerly it was necessary to remove the deposit every month with hammer and chisel. The soapy water flows from a container that is screwed on to the air cylinder through a pipe fitted with a shut-off cock, this lubricant flowing in a stream or merely dropping into the cylinder, according to the extent to which the cock is opened. The mixture passes through the delivery pipe into the compressed-air container, whence it is allowed to run off at intervals, and no injurious action of the lubricant upon the iron parts of the compressor has yet been noticed. J. W. P.

The display of The International Correspondence Schools at the Pan-American Exposition, Buffalo, has just been completed, and compares very favorably with the surrounding exhibits of other educational institutions. It is situated in the northeast corner of the Liberal Arts Building, where an inclosure has been erected for all educational work.

The object of the display has been to illustrate the system of education rather

than to advertise the schools, and it is for this reason that the cases do not contain representative instruction papers from each of the courses. Sample question papers, and students' written replies thereto, in arithmetic, and others in electrical, mining, commercial, architectural and design courses, show the method of examining the student and the character and appearance of his replies to these examination papers. Drawing plates from all the courses, representing the elementary and advanced work of students, show the progress that can be made by this system in drawing, and designs for book covers, wallpapers, etc., executed by students, show what can be accomplshed by the design course in the training of the craftsman.

When visiting the Fair, this exhibit will be found extremely interesting, and it also affords an opportunity to compare the schools' methods with those of the other important educational institutions in this country.

The great advantages of the power drill over hand drilling are best observed in hard rock. In this case the power drill will effect economy in time any money. The speed with which the work will proceed may be taken as three times as fast as with hand drilling. The cost per foot will not be much less for power drilling as against hand drilling. In soft rock it may often be the case that hand drilling is cheaper and more satisfactory than power drilling. We have before us a record kept of drifting in one of the large Colorado mines during a period of six months. The following were the costs for drifting, per foot: Hand drilling, $3.37; drilling with three-inch drill, $5.31; drilling with two and one-half-inch drill, $3.05. In considering the economy of rock drilling one should not, however, compare the mere cost of driving per foot; there are many other considerations. Take, for sake of simplicity, a mine which is in course of development, take the standing expenses to be $750 per month; pumping, etc., $1,000 per month; total expense, $1,750. This expense is incurred in mere administration, pumping, hoisting, etc. Now, suppose the development by hand took a year and that 2,000 feet of drifting was done at a cost of $3.50 per foot. The year's expense account would show $28,000. Suppose, however, this work was done by power drills in six months at a cost of $4.50 per foot, then the total expense account would show $19,500, or a saving of $8,500 in money and six months in time. The mere cost of doing a certain piece of work is only one feature to be considered in mining.

Air motor car No. 578, the first one of the new cars to be placed in commission by the Rome City Street Railway Company, drew three trailers loaded with passengers from Riverside Park to the American corner in twelve minutes, including five stops.

This performance, which is entirely out of the ordinary for any street railway power, makes convincing and conclusive the greater strength and superiority of the improved air cars

Car No. 578 left the power station with 2,000 pounds' pressure, made the trip and return with 850 pounds air used. With the comparatively empty trailers 350 pounds of air were exhausted in making the run to Riverside, and with all cars full only 150 pounds in excess of this amount were used on the return run. The distance of the round trip is three miles.

The total number of passengers on the return trip was 248. The motor with the train of loaded trailers made the run easily and smoothly and took the two short curves without a strain. The steep grade at the East Thomas street bridge gave the motor its severest test and, though the summit was necessarily mounted at somewhat slower than the usual speed, there was no hesitation in the working of the power car. As the train passed over the bridge there was a burst of applause from the passengers.

Notwithstanding the fact that two of the State bridges over the canals cannot be crossed with passengers because pronounced unsafe bv the Railroad Commission, the street railway shows a good business with the new motors. Yesterday the number of passengers carried was 1,214, and the receipts from the work of two motor cars on a handicapped line were $58.73. About three-fifths of this sum was received from the Belt line and two-fifths from Floyd avenue.

A correspondent of *The Engineer* living in California recently described a noval method of economizing in fuel. The plant which is installed at a mine comprises

two horizontal return tubular boilers 54 inches in diameter by 16 feet long, one 12 by 12-inch double cylinder hoisting engine, a 14 by 22-inch duplex air compressor and a smaller steam engine for driving a rock breaker and ventilating fan. The fuel is crude oil, presumably the product of the Southern California wells. The hoisting and rock breaker engines are steam driven, while a 150 horse-power Westinghouse induction motor drives the compressor, which furnishes air at 80 pounds pressure for the rock drills. The air compressor was formerly considerably underloaded for the greater part of the time, being worked about 50 per cent. of its capacity.

It appears that the electric company will not furnish at this point less than 200 amperes, at a potential of 600 volts, at anything approaching a reasonable price, and inasmuch as this amount of current must be paid for whether used or not, it was determined to put it to some use with the present apparatus. The motor and air compressor are now worked to their full capacity and the excess of air forced into the steam boiler. At times when the load on the hoisting and breaker engines is very light the compressed air becomes the only motive fluid, the consumption of oil under the boiler falling almost to zero, the boiler merely serving as a heater for the compressed air, while with the usual load the steam is employed to make up the deficiency. The saving in oil under the average full load is claimed to be 250 gallons in 24 hours, which amounts to about $10 per day.

The greatest difficulty experienced in thus utilizing the compressed air is said to be in securing proper lubrication of the engine cylinders. The steam is exceedingly dry, and when the load is reduced beyond a certain amount the quantity of steam furnished is insufficient to provide the required amount of condensation for the lubricators. It is stated in this connection, however, that this difficulty can readily be overcome by employing force feed lubricators, the use of which is anticipated should the existing conditions continue for any great length of time.

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677,444. STONE-CUTTING MACHINE. Fritz Eisenbeis, Wellesweiler, and Ferdinand Garelly, Jr., Saarbrucken, Germany. Filed Oct. 15, 1900. Serial No. 33,138.

677,454. APPARATUS FOR CUTTING INTO AND OUT OF CIRCUIT LIQUID RHEOSTATS OPERATED BY MEANS OF COMPRESSED AIR. Koloman von Kando, Budapest, Austria-Hungary. Filed Dec. 31, 1900. Serial No. 41,654.

677,536. INDIRECT AIR-CIRCULATING SYSTEM FOR COLD-STORAGE APPARATUS. Madison Cooper, Minneapolis, Minn. Filed Nov. 19, 1900. Serial No. 36,966.

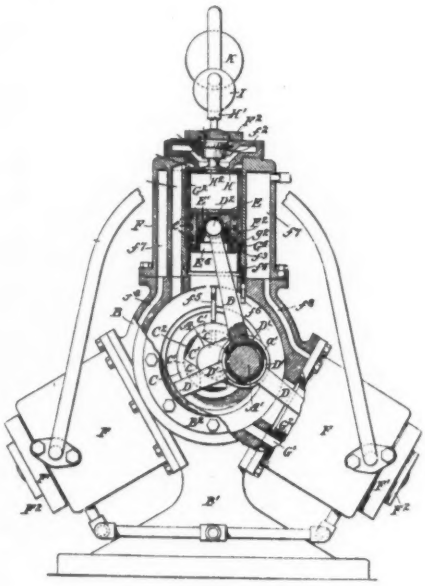
677,562. PNEUMATIC PICKER-CHECKING DEVICE. Frank B. Comins, Sharon, Mass. Filed Jan. 14, 1901. Serial No. 43,118.

677,699. GAS AND AIR MIXER. Gustav Raap, Berlin, Germany, assignor to the "Selas" Geselischaft mit Beschrankter Haftung, same place. Filed Nov. 21, 1898. Serial No. 696,994.

677,710. AIR-PUMP FOR PNEUMATIC TIRES. George B. Stacy, Boston, Mass., assignor to Alexander H. Spencer, New York, N. Y. Filed No. 13, 1900. Serial No. 36,357.

677,759. PNEUMATIC-DESPATCH-TUBE APPARATUS. James T. Cowley, Lowell, Mass., assignor to the Lamson Consolidated Store Service Company, Newark, N. J. Filed Aug. 23, 1899. Serial No. 728,149.

677,503. COMPRESSOR. William J. Francke, New Brunswick, N. J., assignor to the Brunswick Refrigerating Company, same place. Filed Jan. 4, 1900. Serial No. 324. The combination with the piston, and its



cylinder having an annular valve-port in its head, of an open-ended sleeve surrounding the said piston and in frictional contact therewith for operation thereby to open and close said valve-port; correspondingly-opposed annular shoulders being formed on the cylinder and sleeve between their ends and between which is formed a close cushion-chamber, and a fluid-supply for said chamber.

677,810. PNEUMATIC TIRE. Uzziel P. Smith, Chicago, Ill., assignor of one half to Thomas Kane, same place. Filed Oct. 17, 1900. Serial No. 33,373.

677,874. HOISTING-CRANE. James Macbeth, Buffalo, N. Y. Filed July 23, 1900. Serial No. 24,485.

677,928. TERMINAL FOR PNEUMATIC CARRIERS. Harry Bitner, Berwyn, Ill. Filed Feb. 25, 1901. Serial No. 48,645.

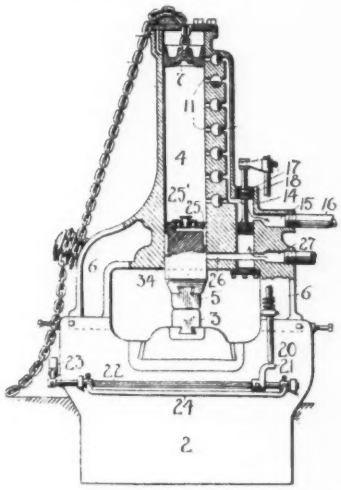
677,983. PNEUMATIC TIRE FOR BICYCLES. Edwin Hemsted, Toronto, Canada. Filed Dec. 14, 1900. Serial No. 40,199.

678,119. SWITCH-VALVE FOR PNEUMATIC CONVEYERS. Thomas Lee, Home City, Ohio. Filed Nov. 13, 1899. Serial No. 736,778.

678,231. PNEUMATIC OR HYDRAULIC MILKING APPARATUS. Clemens von Bechtolsheim, Munich, Germany. Filed June 17, 1899. Serial No. 720,979.

678,450. PNEUMATIC HAMMER. Melvin A. Yeakley, Cleveland, Ohio. Filed Oct. 12, 1900. Serial No. 32,836.

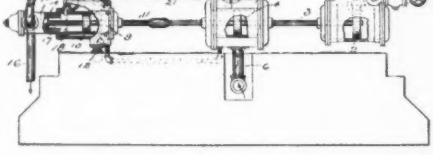
A drop-hammer and the chamber therefor, a series of passages connecting said chamber at different elevations with a fluid-passage for the hammer-operating medium, and valves



to open and close said passages and fluid-passage.

The hammer frame and chamber and the sliding hammer therein, a series of passages open to said chamber at different elevations, valves for said passages, a single passage for the fluid operating media leading to said passages, and a separate valve for said single passage.

678,487. AIR-COMPRESSOR. Ebenezer Hill, South Norwalk, Conn. Filed April 19, 1901. Serial No. 56,584.



An air-compressor having a cylinder with a single-acting piston, a cooler, a duct connected with the chamber on the active side of the piston and extending through the cooler, and a duct connecting the chamber on the inactive side of the piston with the cooler-duct before it passes through the cooler.

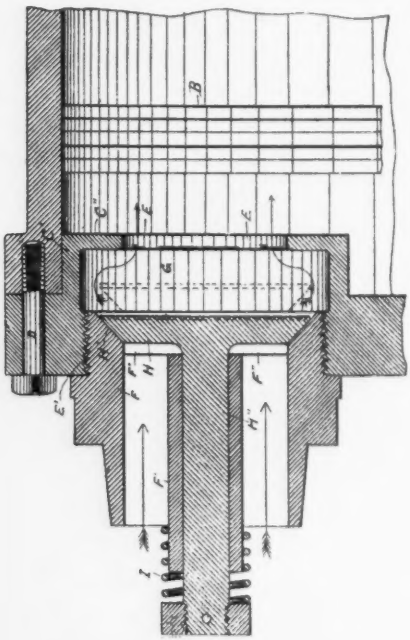
An air-compressor having a plural number of cylinders with pistons, coolers, ducts connected with the chambers on the active sides

of the pistons and extending through the coolers, and a duct connecting the chambers on the inactive sides of the pistons with a cooler-duct before it passes through a cooler.

An air-compressor having cylinders with a double-acting and two single-acting pistons, a cooler, a duct connecting the chambers on the active sides of the single-acting pistons and extending through the cooler, and a duct leading from the chamber on the inactive sides of the single-acting pistons to the cooler-duct before it passes through the cooler.

678,839. AIR-COMPRESSOR. Clarence B. Little, Dayton, Ohio, assignor to the Brownell & Co., same place. Filed April 27, 1901. Serial No. 57,760.

An air-compressor, the combination with a



compressor-cylinder, of a head secured thereto, the said head projecting into the cylinder and providing a chamber adapted to contain a valve and into which valve is movable, an opening in said head forming a communication between the cylinder and said chamber, the diameter of such opening being essentially smaller than the diameter of the valve so that in the event of a breakage of said valve, it will not be permitted to enter the cylinder, a valve-casing mounted in said head, the said valve-casing and the valve forming the outer limit of the chamber.

678,504. PNEUMATIC TIRE. Joseph G. Moomy, Erie, Pa., assignor to Lake Shore Rubber Company, same place. Filed Feb. 16, 1901. Serial No. 47,678.

678,510. PNEUMATIC TIRE AND INNER TUBE THEREFOR. Charles G. Page, Oakpark, Ill. Filed June 7, 1901. Serial No. 63,602.

678,534. VALVE FOR FLUID COMPRESSORS AND ENGINES. Charles A. Bennett, Dover, N. J. Filed July 15, 1898. Serial No. 686,076.

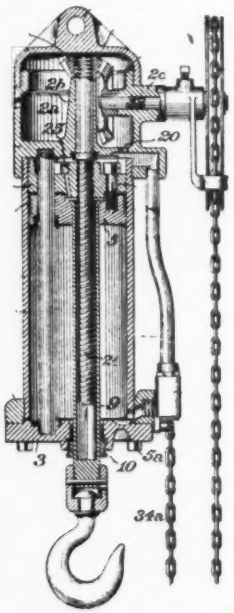
678,570. MOTOR. William A. Jones, West Brighton, N. Y. Filed Oct. 22, 1900. Serial No. 33,862.

678,625. PNEUMATIC PANNING OR DISTRIBUTING MACHINE. Henry J. Perky, Worcester, Mass. Filed Sept. 29, 1900. Serial No. 31,554.

678,759. PORTABLE FLUID-PRESSURE HAMMER. Walter Payton, Richmond, England. Filed Dec. 10, 1900. Serial No. 39,399.

679,421. PNEUMATIC HOIST. William S. Halsey, Pittsburg, Pa. Filed May 28, 1901. Serial No. 62,295.

A pneumatic hoist, the combination of a

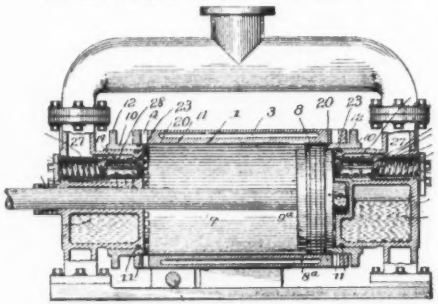


fluid-pressure cylinder a piston fitting therein, a rod fixed to said piston and adapted to be connected to a load, means for admitting and releasing fluid to and from the cylinder, a regulating-screw engaging a nut on the piston and rotatable by the traverse thereof, means for preventing rotation of the piston, and means for controlling the speed of rotation of the regulating-screw.

679,235. AIR OR GAS PUMP. John Patten, Baltimore, Md., assignor to the Patten Vacuum Ice Machine Company, same place. Filed June 23, 1900. Serial No. 21,303.

679,335. AIR-COMPRESSOR. David Pryde and Henry Gauerman, Braddock, Pa., assignors to the Braddock Machine Manufacturing Company, same place. Filed Aug. 24, 1900. Serial No. 27,875.

An air-compressor the combination with a



cylinder having a stationary body and heads, said body being provided with an annular row of air-inlet ports at each end, of a piston in said cylinder, rings movable over said heads and projecting into said body, and means for moving said rings to alternately cover and uncover said ports.

679,343. COMPRESSOR. William F. Singer, New York, N. Y., assignor to the Singer Automatic Ice Machine Company, Jersey City, N. J. Filed Nov. 15, 1900. Serial No. 36,612.

679,437. FLUID-PRESSURE ENGINE. Eli A. Stark and Thomas Winship, Toledo, Ohio, assignors to the Toledo Steam and Air Motor Company. Filed March 29, 1900. Serial No. 10,654.

679,519. VALVE FOR PNEUMATIC TIRES. Lyman T. Smith, New Haven, Conn. Filed Dec. 31, 1900. Serial No. 41,650.

679,533. CONTROLLING VALVES OF FLUID-MOTORS. Edward Y. Moore, Cleveland, Ohio, assignor to the Chisholm and Moore Manufacturing Company, same place. Filed March 27, 1901. Serial No. 53,030.

679,534. SYSTEM OF CONTROLLING PNEUMATIC MOTORS OF CRANES, HOISTING MECHANISM, &c. Edward Y. Moore, Cleveland, Ohio, assignor to the Chisholm and Moore Manufacturing Company, same place. Filed May 15, 1901. Serial No. 60,321.

679,587. APPARATUS FOR COLLECTING GASES, VAPORS AND FOREIGN PARTICLES FROM AIR. John Zellweger, St. Louis, Mo. Filed Sept. 26, 1899. Serial No. 731,727.

679,670. REPEATING AIR-RIFLE. Clarence J. Hamilton, Plymouth, Mich., assignor to the Daisy Manufacturing Co., same place. Filed Dec. 24, 1897. Serial No. 663,435.

679,716. COMPRESSOR AND PUMP. Arthur G. Enock, Willesden, England. Filed Jan. 18, 1901. Serial No. 43,806.

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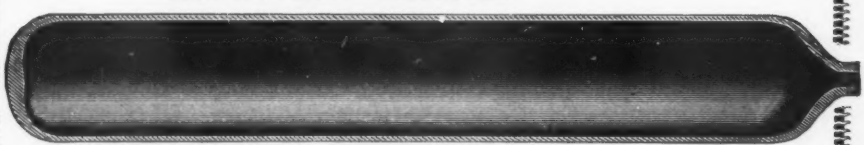

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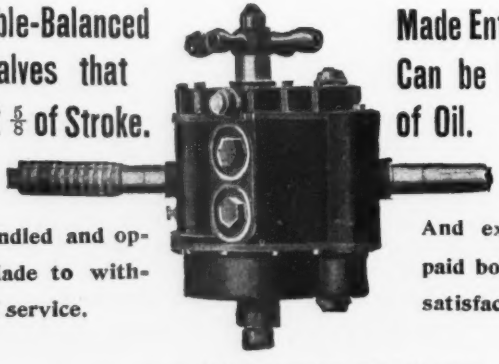

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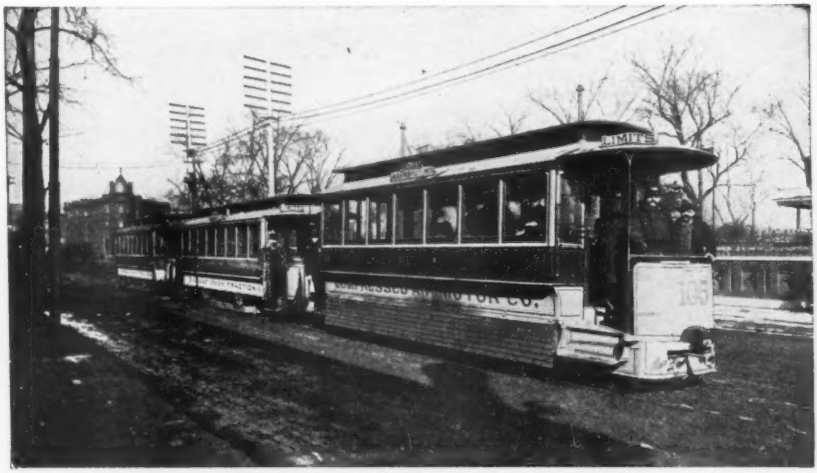

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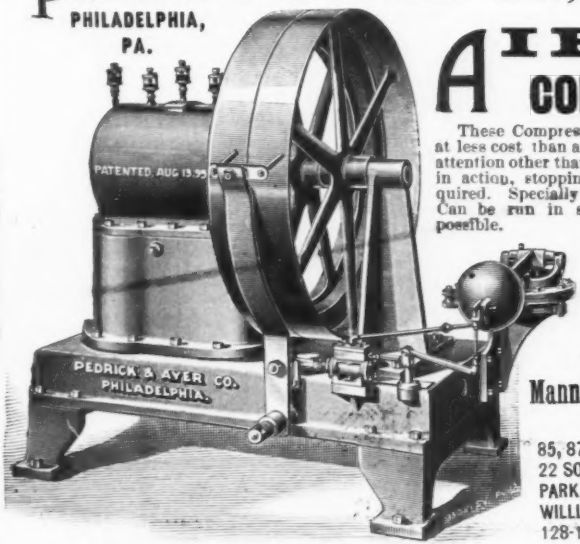

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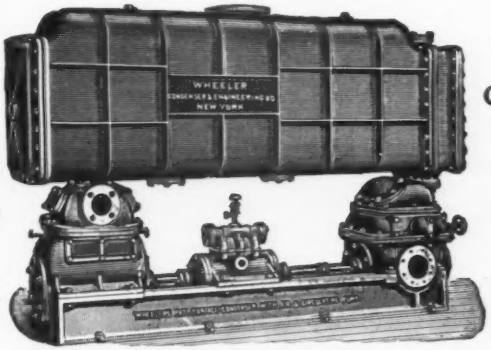

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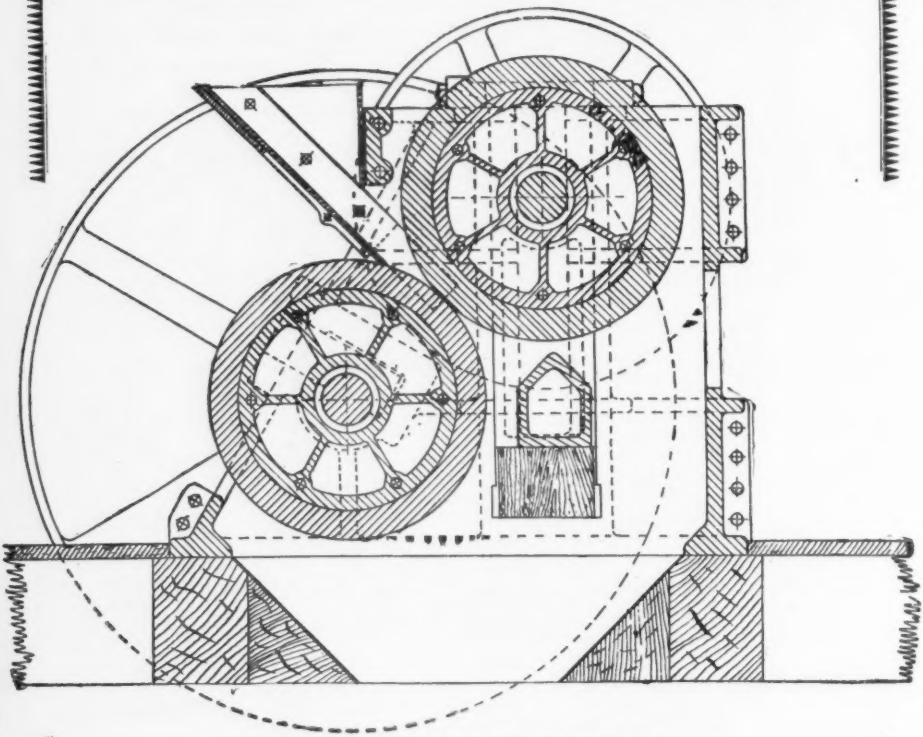

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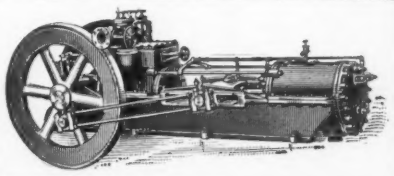

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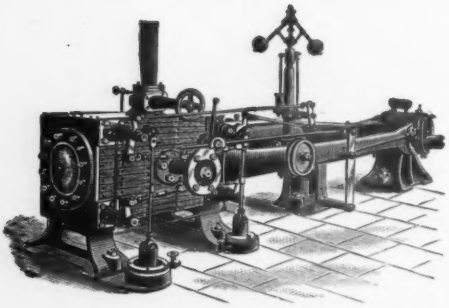

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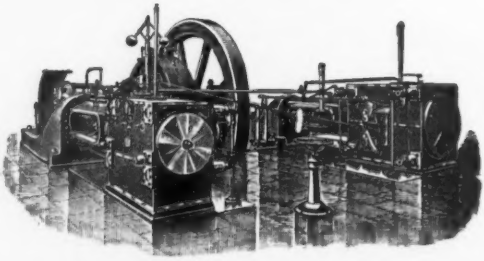

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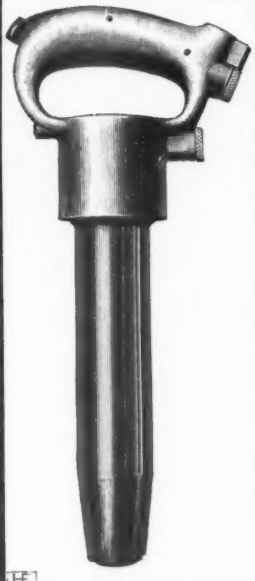

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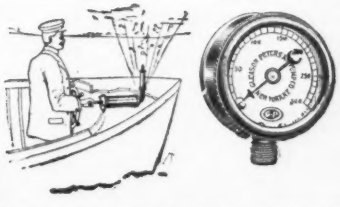

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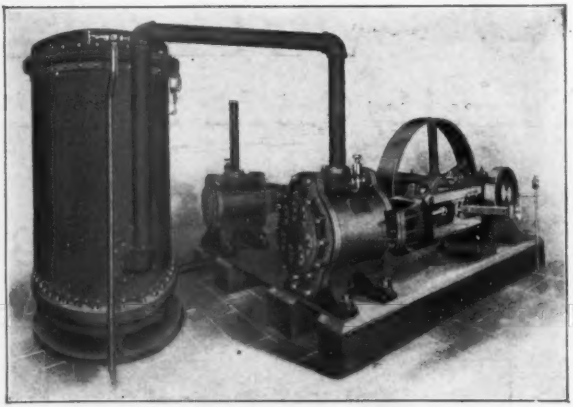

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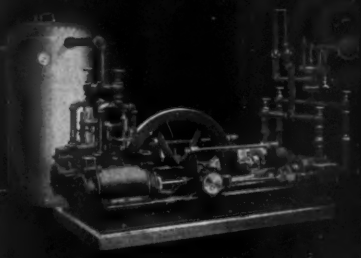

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